# EDITORIAL

WHAT has become of the people that were so anxious to investigate graft and inefficiency at Hog Island?

SHIPS launched for the Emergency Fleet Corporation during July had a total capacity of 631,944 tons or more than double the tonnage of any preceding month.

AUTOMOBILE manufacturers have been requested by the War Industries Board to get their plants on a 100% war-work basis, if possible, by January 1, 1919.

THE first rivetless steel vessel was launched recently at a British port, all joints being made by electric welding. A saving of 20% of both time and material is claimed over the ordinary methods.

CENTRALIZED control of county highways has been endorsed by the Farm Bureau of Sonoma county, California, which has adopted a resolution requesting the Board of Supervisors to appoint a competent man to have full control of road construction and maintenance in the county.

THE famous case of Jarndyce v. Jarndyce, which was dismissed because the estate was swallowed up in costs, was recalled in a water-suit in Tulare county a few weeks ago. Two irrigators carried a dispute over the division of water from a certain stream to the Superior Court of the county. Meanwhile the stream dried up. 'Case dismissed; costs divided.'

HIGHWAY construction of practically every kind after September 10 will require the approval of the United States Highways Council. This approval will be limited, as far as possible, to streets and highways that are an actual war-necessity. First consideration is to be given to the maintenance of highways already completed. Re-construction will receive favorable consideration only when it is clear that maintenance is no longer possible except at prohibitive cost.

SOME interesting statistics of our shipbuilding program are given in a recent issue of 'Emergency Fleet News.' At the time the United States entered the War, there were 37 yards for building steel ships and 24 yards for building wooden ships. These yards have been enlarged and others built until there are now 162 yards in all, of which 118 are practically completed. These yards will contain 819 ways, of which 750 are for the use of the Emergency Fleet Corporation, 50 for the Navy, and 19 for private vessels. The ways for the Navy are in addition to those at navy yards. Including yards for concrete ships, there will be 56 yards on the Pacific Coast and 256 ways. The great Hog Island yard is 90% complete and the first ship, the 7500-ton freighter 'Quistconck,' was launched from there on August 5.

SURVEYING instruments, particularly plane-tables and alidades, are needed by the War Department. Engineers having such instruments that they are willing to sell should write to the Department Engineer, Santa Fe building, San Francisco, stating kind, type, catalogue number of maker, original cost, year purchased, present condition, and lowest cash price delivered in San Francisco. At the present time no arrangement has been made that will permit lending instruments to the Department.

FLOOD-CONTROL on the Santa Ana river is considered in a report prepared for the authorities of Riverside, San Bernardino, and Orange counties by Messrs. J. H. Quinton, F. H. Olmsted, A. L. Sonderegger, and W. K. Barnard. The measures recommended include storage-reservoirs, spreading of water on the gravel cones, rectification of the channel, and bank-protection. Besides protecting a considerable area of land now subject to occasional overflow, the project would provide water for 40,000 acres of land that is not now irrigated.

THE labor policy of the Emergency Fleet Corporation will, as far as possible, include no disturbance of existing shop conditions. Where a 'union shop' exists, it will be continued, but where 'open-shop' rules prevail, with no discrimination between union and non-union employees, this condition will also be undisturbed. Women employees are to receive equal pay for equal work. The eight-hour day is to be enforced where existing laws require it. In other cases, the welfare of the workers is to be considered in determining hours.

HONORS in shipbuilding construction continue to be the exclusive property of Pacific Coast yards. During June, the best performance among the steel-ship yards was made by the Skinner & Eddy Shipbuilding Corporation of Seattle. Second place was awarded to the Union plant of the Bethlehem Shipbuilding Corporation at San Francisco, and third place to the Columbia River Shipbuilding Company of Portland. First and second places among the wooden-ship yards are given respectively to the Portland and Aberdeen yards of the Grant-Smith-Porter Ship Company, the Supple-Ballin Shipbuilding Corporation of Portland being third.

THE Division of Engineering, United States Employment Service, recently established under the direction of Mr. A. H. Krom, with headquarters at Chicago, has already made a record of accomplishment. During

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one month 468 applications for help were received from employers and 1314 applications for positions, while 483 positions were actually filled. At present, since the Federal government is the largest employer of engineers in the country, the most useful service of the Division of Engineering is in placing men in the Government service. Engineers that would be willing to accept Government positions should file a statement of their qualifications and record with the Division. Blanks may be obtained from the Chicago office.

THE ill wind that blows somebody good appeared off the coast of Monterey bay a few weeks ago. The citizens of Monterey have wished for a long time to construct a nice new pier to take care of the growing commerce at that port. But money has been hard to obtain, and deliveries of materials almost as hard. Meanwhile a large raft of logs was towed from 'a Pacific port,' destined for another Pacific port. Trouble attended the towing almost from the start, but the climax came about opposite Monterey, when most of the logs broke loose and could not be recovered. The good people of Monterey are now picking up these logs as they drift to the shore, and when they get enough will start construction of the pier.

A CENTRALIZED State government combined with the short ballot has been proposed in Oregon. Only three State officials are to be elected by the people, the Governor, State Treasurer, and Secretary of State. All other heads of departments are to be appointed by the Governor. The State government will be divided into nine departments: executive headed by the Governor, general administration and finance, and education, each in charge of commissions, and departments of labor, public health, agriculture, trade and commerce, public welfare, and public works and domain, each in charge of a single director. The estimated saving per year is $418,000, without considering any possible saving due to increased efficiency.

THE new selective draft law will probably have been signed by the President by the time this issue reaches our readers. It is unnecessary to recount the reasons for this law. The Central Powers must be defeated overwhelmingly, and the sooner this is done the less will be the cost in life and even in property. The success of our shipbuilding program shows that it will be possible to place and maintain 3,000,000 men in France by the spring of 1919 and a million or so more during that year if necessary. To get these men we must put a uniform on every available man between 18 and 45. Registration of the men between 18 and 21 and between 32 and 45 will be an even greater task than was the original registration a year ago, and will require the co-operation of everyone if it is to be as successful as was the earlier registration. Employers should not only register themselves, if within the stated ages, but should also see that their men understand the necessity for registering and that they are allowed time to do so. Further information regarding the law will be found on page 16 of our advertising section.

## Announcement

The October issue will appear under a new name—METAL TRADES. The reasons for this change may be stated in a few words; they are the growth of the iron and steel manufacturing industry of the Pacific Coast, and the consequent need for a medium of publicity adequately to serve its needs. Through METAL TRADES we aim to supply those needs.

In 1914, the metal trades of the Pacific Coast were moribund, if not worse. No more discouraging state of affairs could well be imagined. Now look about, and see the change. The manufacturers of the West have found, to their surprise, that they can make machinery and ships—excellent machinery and excellent ships—more quickly than many others, and probably just as cheaply. The United States government has found this out, and has placed orders to such an extent that Western iron-works are loaded with business to capacity and beyond for months if not years in advance.

Shops of all sizes have profited. Quantities of details and auxiliaries are sub-let. Everybody is taking a hand in the construction of Pershing's bridge to France. To meet the extraordinary demands, manufacturers have increased their facilities from 50 to 100%. They have bought new equipment, machine-tools, land, and buildings in unheard of quantities. They have invested millions in this way, most of which is borrowed capital, and capital has a little brother from which it is inseparable, interest.

Who is going to pay the interest when the war-orders cease?

Here is a chance for real constructive organization, that will help to create new markets for the output of these plants. Here is the chance for METAL TRADES.

METAL TRADES will concentrate every effort, through the constructive use of printer's ink, to supply a medium of publicity whereby the manufacturing facilities of the Pacific Coast may be introduced to those who can employ them. It will strive for better manufacturing methods, better engineering, and more efficient selling. Through the interchange of ideas of mutual benefit, all may profit, and the enormous war-time investment in fixed improvements may be made to produce through catering to the inevitable demands of reconstruction. There must be no backward step, no recession to the stagnation of 1914.

METAL TRADES has been endorsed officially by the California Metal Trades Association. This body of manufacturers was organized for the purpose of co-operation and mutual help in meeting and solving all problems affecting the industry. The publishers of METAL TRADES will work with it to accomplish these ends. We feel justified in promising to our readers a better, more interesting, more useful journal than before; to our advertisers, a medium of publicity far greater in value.

This may sound like a large contract. It is. Nevertheless, we shall make the effort, in the belief that with a good cause a battle is half won. With the co-operation of those whom we serve, we shall succeed.

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# REVIEW OF THE MONTH

OIL-PRODUCTION in California for June exceeded consumption for the first time in several years. The average production was 283,000 barrels per day, while the consumption was 278,000 barrels per day. The consumption has been as high as 300,000 barrels per day during the past year, while the production until recently has been around 260,000 barrels. The reduction in consumption is partly seasonal, but is mainly the result of changing from oil to other fuel, particularly in the North-West, and to increased economy by all users. These various factors have compensated for the increased use by war industries and also by the power companies on account of the shortage of hydro-electric power. The increase of production comes mainly from the new Montebello field near Los Angeles and from the revived Casmalia field in Santa Barbara county. The production from the Montebello field is about 16,000 barrels per day and from the Casmalia field nearly 5000 barrels per day. The older fields of the State are simply holding their own.

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THESE figures are encouraging, but producers and consumers of oil are far from being out of the woods yet. The war industries have not reached their maximum demand and it will probably be several months before the coming of the winter rains will permit the power companies to reduce their use of fuel-oil. Furthermore, the production from old wells is certain to decrease and it is important that new wells be drilled in districts that will yield the maximum amount of oil for the minimum expenditure of labor and material. Legislation that will permit development of the withdrawn unpatented lands is just as much needed as it ever was, but action by Congress seems improbable.

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POWER shortage in northern California reached another stage with the issuance of orders for curtailment of deliveries of power to several industries. Power consumption in northern California has been at a rate of 5,000,000 kilowatt-hours per day. This load would have emptied the storage-reservoirs of every power company north of Merced on or about October 17, leaving the entire load to be carried by the steam generating-plants and by the normal flow of the streams until the winter rains come to relieve the situation. Unless heavy rains come in September or early in October, which is improbable, it is evident that this course would compel a curtailment of power-deliveries in the latter part of October that would cripple the most essential industries of the State. To avert such a calamity, measures have been taken to reduce power-deliveries to the cement-plants, gold-dredges, and sand, gravel, and rock plants, which have been using 5,000,000, 11,000,000, and 3,000,000 kilowatt-hours, respectively, per month. The cement-plants will now receive half their former amount of power, and the gold-dredges and sand, gravel, and rock plants two-thirds. The amount of both building and highway construction has been so much reduced already that, as far as the cement, sand, gravel, and rock plants are concerned, the new order will work little hardship except for those directly connected with these industries. The gold-dredges, however, are a different matter. Gold has been declared an essential commodity. Dredges produced 41% of the gold obtained in California in 1917. Furthermore, dredging-companies, as a rule, have lower costs per ounce of gold recovered than mines, and are, therefore, better able to stand the present high cost of labor and material that is compelling some of the best mines in the State to suspend operations.

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WHAT will be the next industry to feel the axe of reduced deliveries? Apparently the present order will postpone the evil day of empty reservoirs for less than two weeks. Manifestly this is not enough. Further curtailment may be expected. The largest users of power are the electric railroads, taking 22,000,000 kilowatt-hours per month. Next comes irrigation with 15,000,000, and lighting, with 13,000,000. Most of the other large users of power would be classed as essential war-industries, and, if anything, should have their allotments increased. The production of food is so important that irrigation cannot be curtailed, but the amount of power needed for irrigation will decrease from this time. This will probably offset increased needs for power in the war-industries. Lighting and the operation of electric railroads remain for consideration. Some decrease, not only in municipal, but also in commercial and residence lighting, can be made, also a reduction in the number of cars operated outside of the rush-hours. It is probable that all of these measures will have to be adopted soon.

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HOW long is it going to take for some people to realize that the country is at war? Members of the Board of Supervisors of San Francisco, finding themselves with a little money on hand as part of the city's share of the State motor-vehicle tax, are casting about wildly for a method of spending it. Ignoring the execrable condition of many of the streets adjacent to the plants engaged in war work, they propose to spend $100,000 on repaving two miles of the so-called Great Highway along the ocean front. This highway is a very nice peace-time luxury, but the wildest imagination could not call it a war-time necessity. Commercial traffic it has practically none; joy-riding traffic it has a great deal,

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but even this will probably be reduced materially when the country goes on a dry or a semi-dry basis. Yet this proposed waste of the public money is said to be endorsed by the various automobile clubs and by several civic organizations. We are glad to see that Mr. John Perrin of the Federal Reserve Bank has entered a protest.

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SIMILAR disregard of war necessities, although for a more worthy purpose, is shown by the Board of Supervisors of Merced county, California, which has decided to submit the question of issuing $1,250,000 worth of bonds for the construction of a county highway system to the voters at the November election. As many of our readers will remember, this project has been under consideration for several years. Recently Mr. W. H. Lynch, engineer for the U. S. Office of Public Roads, visited the county and made a study of its highway problems. His report recommended some construction and repair work at the present time, and the building of a county highway system after the War. We have not been informed whether or not the supervisors have brought the project before the Capital Issues Committee, for endorsement, which endorsement will, of course, be necessary before the bonds can be sold. It is, however, hard to see how the Capital Issues Committee can be persuaded to overrule Mr. Lynch's recommendation. Merced county is almost entirely a farming district, with no large cities and few industries except those connected directly with agriculture. The only excuse for spending a large amount of money on highway construction would be that such work would materially assist the movement of crops. However, the county is traversed by the principal State highway through the San Joaquin valley and by several main lines of railroad. There is little of the productive agricultural area that is more than ten miles from a railroad. Most of the crops produced are moved at seasons of the year when the unimproved roads, while dusty, are not impassable. Furthermore, allowing a reasonable length of time for the sale of bonds, making of surveys and plans, awarding of contracts, and actual construction, the completion of any large amount of paved road in time to be of help in moving the crops for the season of 1919 is not probable. In fact, when the unavoidable interference with traffic during construction is considered, the building of such a highway system would probably be a hindrance rather than a help to food-production in 1919. When food production in 1920 is considered, several other factors enter into the problem. Hostilities may or may not be over by that time, although there seems to be good reason to expect that they will. But it is reasonably certain that before that time our shipbuilding program will have progressed far enough so that ships carrying supplies to Europe will not have to be kept on the shortest runs. Stores of food can then be equalized in all the Allied countries at least, instead of the present conditions of scarcity in Europe and a surplus in Australia and other countries. No one denies that a system of paved highways in Merced county in 1920 would be a convenient thing, but the question is, should a large quantity of labor and materials be withdrawn from actual war work in 1919 in order to construct such a system?

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PERHAPS the county authorities have no intention of selling bonds at the present time, but merely wish to obtain the approval of the voters for the project, and will then postpone actual construction until after the War. If this is their intention, it is a waste of time and white paper to put the measure on the ballot now. At present, a system of improved county highways seems to be the most important peace-need of the country. When peace finally comes, some entirely different project may claim attention. From every standpoint of public policy, the proposed bond issue should be defeated.

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SUBMARINES are discussed recently in a bulletin by the Naval Consulting Board in co-operation with the Engineering Council, which has been sent to members of the national engineering societies. The present bulletin adds the information derived during the past year to that contained in the bulletin issued soon after the United States entered the War. Disregarding the many absurd methods proposed for dealing with the submarine problem, the bulletin discusses the plans proposed that have some claim for consideration. 'One-man' submarines, whether acting independently or with a mother-ship, are impractical. So also are nets, guards, or any other method thus far proposed for arresting or deflecting a torpedo. Decreasing the visibility of vessels by the use of either smokeless combustion, smoke screens, or 'camouflage' painting is of considerable assistance. Blinding enemy periscopes by pouring heavy oil on the water has been tried but it is of little service. Speed of vessels is a great advantage. The number of vessels having a speed of over 15 knots that have been attacked successfully is small. Water-tight compartments and similar devices are useful but have their limitations. Convoys furnish almost complete protection to the vessels so accompanied, but many commanders of fast vessels prefer to trust to speed rather than travel at the slower rate that the convoy-system makes necessary. Many listening devices for detecting the presence of submarines are now in use and the improvement of such devices furnishes an important field for the inventor. Turning to offensive measures, confining the submarines to their bases would, of course, solve the problem, but this has so far been accomplished only in part. Nets, trawling, aeroplanes, and other submarines all have their places. Depth-charges and gunfire are both used in destroying submarines, special shells being made for penetrating the water satisfactorily.

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THE last toll-road on the Lincoln highway was eliminated recently when the Pennsylvania State Highway Department purchased the Lancaster and Susquehanna turnpike in Lancaster county. It is now possible to travel from New York to San Francisco over the Lincoln highway without paying toll-charges, except at a few bridges.

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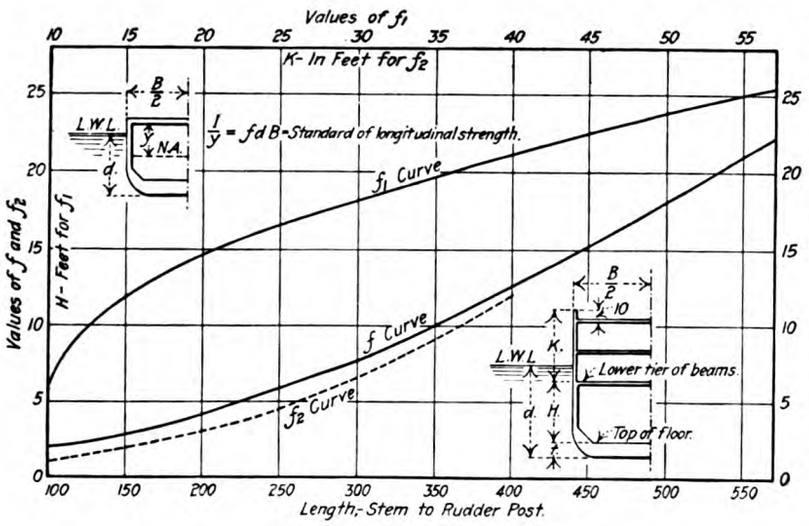
# The Design of Concrete Ships

By H. DEVEREUX*

The length of a concrete ship should be 6 times the beam and 12 times the draft. In Genesis VI, 14-15, we read that the fashion of the Ark was 6 beams and 10 depths in the length, pitched inside and out. The pitch is applied today under different trade-names. In Chronicles II, 16, we find that they brought wood for the temple at Jerusalem in floats to Joppa, but employed strangers to fabricate it. This also is the method today. The great classification societies furnish rules and sizes for the construction of merchant vessels for reasons given in Proverbs XXX, 18-19, but as surely as the 'Way of the eagle in the air' has been solved by the aeroplane, so will the 'Way of a (concrete) ship in the sea.'




VALUES OF $f$, $f_1$, AND $f_2$.

Steel ships are designed according to the published rules of one or other of the great classification societies. These rules are the results of years of observation as to the effect of the sea upon ships. Until the English Load Line Committee published the result of several years' investigation on the strength of ships, the usual statement was "Ships cannot be figured. Follow Lloyds'," and the text-books confirmed this impression. Dr. Bruhn's elastic curve and the tests made on HMSS. 'Wolf' being the ones generally cited. As a basis of comparison of the longitudinal strength of steel ships, the Load Line Committee proposed the formula:

Longitudinal moment of resistance $= fdB = \frac{I}{y}$.

where $I$ = moment of inertia of the midship section in square inches.

$y$ = distance from the neutral axis to the underside of the strength-deck stringer.

$d$ = draft in feet.

$B$ = breadth of ship.

$f$ = a coefficient.

In computing $I$, all longitudinal continuous members are included except such as are required for pillaring. Above the strength-deck, the gunwale angle-bar and the extension of the sheer-strake only are included. No deduction was made for rivet-holes. The strength-depth equals the distance from the top of the keel to the underside of the strength-deck at the side of the ship at midsection.

Where $L$ = distance in feet on the summer load-waterline between stem and rudder-post, the values of $f$ are as follows:

| $L$ | $f$ | $L$ | $f$ |
|---|---|---|---|
| 100 | 2.0 | 360 | 10.5 |
| 120 | 2.25 | 380 | 11.5 |
| 140 | 2.6 | 400 | 12.5 |
| 160 | 3.0 | 420 | 13.5 |
| 180 | 3.5 | 440 | 14.6 |
| 200 | 4.0 | 460 | 15.7 |
| 220 | 4.6 | 480 | 16.8 |
| 240 | 5.3 | 500 | 18.0 |
| 260 | 6.1 | 520 | 19.2 |
| 280 | 6.9 | 540 | 20.4 |
| 300 | 7.7 | 560 | 21.7 |
| 320 | 8.6 | 580 | 23.1 |
| 340 | 9.5 | 600 | 24.6 |

Foster King stated before the Institute of Naval Architects in 1915: "For all ordinary vessels, such as those with which we have to deal and many extraordinary ones, it has been found that a close approximation to the greatest bending moment derived by direct calculations is obtained from the formula

$$\text{Bending moment} = \frac{0.8\ dBL}{35 \times 35}$$

where $L$ = length in feet.

$B$ = breadth in feet.

$d$ = winter draft-line.

Twenty years' experience of the application of this formula has shown an agreement of about 5% with the calculated figures furnished by builders for vessels of widely dissimilar character and dimensions and gives evidence of its utility as a guide in strength calculations."

Corresponding to Mr. King's formula we have

$$\text{Bending moment} = \frac{\text{displacement} \times \text{length}}{35}$$

The tension in the sheer-strake is equal to $\frac{My}{I}$

Assume a 2000-ton steel ship with a displacement of 2910 tons, length, 220 ft.; breadth, 35 ft.; draft, 17 ft. 9 in.; molded depth, 20 ft., one-deck type.

$$M = \frac{2910 \times 220}{35} = 18{,}350 \text{ ft.-tons.}$$

$y$ = approximately 11 ft.

$$\frac{I}{y} = fdB = 4.6 \times 17.75 \times 35 = 2850.$$

*Consulting engineer, 20 Montgomery street, San Francisco.

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$I = 2850 \times 11 = 31{,}350$ in. sq.-sq. ft.

Then $\frac{My}{I} = \frac{18350 \times 11}{31350} = 5.85$ tons per sq. in. tension in sheer-strake.

The bending moment divided by the distance between bottom and strength-deck gives the tension in the top or bottom of hull for this 2000-ton ship.

$\frac{18350}{19} = 985$ tons.

$\frac{985}{6} = 164$ sq. in., area of plating required.

Thickness of plating $= \frac{164}{35 \times 12} = 0.40$ in. (Breadth $= 35 \times 12$).

A similar calculation will give the area of reinforcing steel required in the top and bottom of a concrete ship to resist 'hogging' and 'sagging' stresses, as follows:

Assume a 2000-ton concrete ship, displacement, 3680 tons; length, 220 ft.; breadth, 42 ft.; molded depth, 23 ft.; draft, 18 ft.

$M = \frac{3680 \times 220}{35} = 23{,}000$ ft.-tons $\frac{23000}{22} = 1045$ tons.

$\frac{1045 \times 1.12}{8} = 146$ sq. in., area of top steel.

$\frac{1045 \times 1.12}{6} = 196$ sq. in. bottom steel.

The breadth, $B$, may range from $\frac{L}{10} + 5$ to $\frac{L}{10} + 20$, and the length, $L$, from $10D$ to $13.5D$. A strength of 90% in way of the hatches is considered normal. Mild steel with an ultimate strength of 27 to 32 tons per square inch and an elongation of 20% was considered the desirable material to use for steel ships.

### Standard of Transverse Strength

The standard transverse frame is a frame angle and a reverse angle, each of the same size and thickness. The transverse modulus is the moment of inertia of the standard frame divided by $y$, without deduction of rivet-holes.

$$\frac{I}{y} = \frac{s(d-t)(f_1 + f_2)}{1000}$$

where $I$ is expressed in sq. in.-in. sq., and $y$ in inches.

$s$ = frame-spacing.

$d$ = draft in feet from top of keel to centre of disk (load-water-line).

$t$ = vertical distance in feet from top of keel to a point midway between top of inner bottom and top of heel-bracket. If there is no double bottom, measure to a point midway between the top of the floor at the centre and the top of floor at the side.

$f_1$ and $f_2$ are constants.

where $H$ = molded depth minus $t$ for single-deck ships, and distance to lowest tier of beams minus $t$ for double-deck ships.

$K$ = height of superstructure above the lowest tier of beams plus 7 ft. 6 in. under ordinary conditions and 12 ft. 6 in. if there is a superstructure above the freeboard.

then the values of $f_1$ and $f_2$ are as follows; $H$ and $K$ being expressed in feet:

| $H$ | $f_1$ | $K$ | $f_2$ |
|---|---|---|---|
| 6 | 9.0 | 0 | 0 |
| 8 | 11.0 | 5 | 0.5 |
| 10 | 12.5 | 10 | 1.0 |
| 12 | 15.0 | 15 | 2.0 |
| 14 | 19.0 | 20 | 3.0 |
| 16 | 24.0 | 25 | 4.5 |
| 18 | 29.5 | 30 | 6.5 |
| 20 | 36.0 | 35 | 9.0 |
| 22 | 43.0 | 40 | 12.0 |

Assuming the same concrete ship as before, $L = 220$, $B = 42$, $D = 23$, draft $= 18$, type, single-deck, frames spaced 48 in. centre to centre.

Then $d = 18$ and $H = 20$.

$\frac{I}{y}$ = section modulus $= \frac{48(18-3)(36+1)}{1000} = 26.7$.

This would call for an 0.5 by 3.85 by 10 in. ship-channel equal in strength to a 10-in., 30-lb. I-beam. This is the section in the Carnegie Steel Co. handbook that comes nearest to the requirements, and it is listed as capable of sustaining 990 lb. per foot on a 17-ft. span. The following computation is required for the design of a concrete frame of the same strength:

$M = \frac{990 \times 17 \times 17 \times 12}{12} = 285{,}000 = 200\ bd^2$

$f_c = 1000$ lb.

$p = 2\%$

$n = 10$

Assuming a 7-in. width, $d = \sqrt{\frac{285000}{200 \times 7}} = 14.3$ in.

$A_s = 0.02 \times 7 \times 14.3 = 2$ sq. in.

Use two bars 1 in. square.

**Longitudinal Shear.** The shear in the sides of a ship is equal to about $\frac{1}{8}$ of the displacement and is at a maximum at the quarter-points. In the 2000-ton concrete ship having a displacement of 3680 tons, the shear in each side equals $\frac{1}{2} \times \frac{1}{8} \times 3680 = 230$ tons. The Load-Line Committee gives the following formula:

$$t = \frac{Fm}{Iq} = 0.105\,L + 17.$$

where $F$ = maximum shearing-stress at section.

$q$ = shearing-stress at neutral axis.

$m = \frac{1}{2}$ total moment of longitudinal members above neutral axis at that axis.

$I$ = moment of inertia $= d^2h$.

$t$ = thickness of plating in hundredths of an inch.

In the 2000-ton steel ship, $L = 220$, and $t = (0.105 \times 220)\ 17 = 0.40$ in. In the concrete ship, the main shear $= \frac{230 \times 2240}{\frac{7}{8} \times 23 \times 12 \times 4} = 575$ lb. per sq. in., assuming 4-in. sides.

Where the shear exceeds 100 lb. per sq. in., it should all be taken by the steel. A $\frac{1}{2}$-in. square bar is good for 4000 lb.

$\frac{4000}{4 \times 575} = 1.74$ in. Use $\frac{1}{2}$-in. square bars placed diagonally and spaced $3\frac{1}{2}$ in. centre to centre both ways, at the quarter-points, increasing spacing gradually to $8\frac{1}{2}$ in. at stem, stern, and amidships.

$s$ = spacing $= \frac{0.86 \times 22 \times 12 \times 8000}{230 \times 2240} = 3.4$ in.

**Floors of Ships.** The bottoms of the frames of ships

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are called floors. The Load-Line Committee's spacing in inches for frames of standard strength is $0.025L + 17$, for ships over 160 ft. long, with the minimum spacing of 21 in. for lesser lengths. The Committee gives no data as to size. The load that comes upon a dry-dock floor when light equals the pressure-head minus the displacement. Making this assumption for the concrete ship, and remembering that the longitudinal moment of resistance was figured for a trochoidal wave having a height equal to $\frac{1}{20}$ of the length, the 2000-ton ship has a pressure-head of $\frac{23}{35} = 0.66$ tons, figured from the gunwale according to the shipping-board's rules. Displacement per square foot $= \frac{3780}{\frac{1}{8} \times 220 \times 42} = 0.46$ tons.

$(0.66 - 0.46)2240 = 450$ lb. per square foot.

In finding the required floor

$M = \frac{4 \times 450 \times 36}{12} = 19{,}200$ ft-lb. $= 200\ bd^2$.

Assuming a 10-in. beam then

$b = \frac{192000 \times 12}{200 \times 10} = 34$ in.

$34 \times 10 \times 0.02 = 6.8$ sq. in. of steel.

Use a 10 by 36 in. concrete beam with six $1\frac{1}{8}$ in. square bars. This is equivalent to a Lloyds' floor.

Shear $= \frac{1800 \times 18}{28 \times 10} = 115$ lb. per square inch.

$34 - 6 = 28$ in. = the rise in the floor.

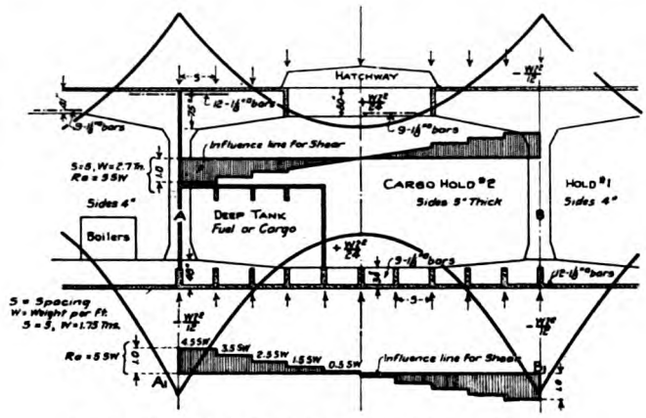
Space stirrups, $4 = \frac{1}{4}\ d$, $4 = \frac{1}{2}\ d$, $4 = \frac{3}{4}\ d$, and the remainder $= d$, beginning at the sister-keelsons.

The Union of Danish Engineers gives the following rules for structural work in reinforced concrete:

The minimum thickness for bottom and sides should be 2.8 in. Flat surfaces less than 3.2 in. thick are to be considered as simply supported, unless so reinforced as to be capable of withstanding bending-moments in both directions. Maximum tensile stress on steel should be 16,000 lb. per square inch. Maximum compressive stress on concrete should be 800 lb. per square inch. When the calculated shearing stress on the concrete exceeded one-tenth the compressive stress, the shearing stress should all be taken by the steel. For 'hogging' and 'sagging,' figure a trochoidal wave with a length equal to the length of the ship and a height equal to 1/20 of the length of the ship. The vessel is assumed fully laden with a homogeneous cargo. For transverse strength, figure the full load, but with the cargo all on one side of the ship, the other side being free. Pressure-head = depth plus $L/40$ divided by 35. No allowance is made for distributing effect of longitudinal girders. The bottom of the hull is taken as a beam, subject to a uniformly distributed load, $q$, and to the bending-moments resulting from horizontal stresses, $H$, applied at the strength-deck gunwale. The side-frames are investigated for the same loading as the bottom as is customary and the deck is figured for a load of 150 lb. per square foot plus its own weight.

### Strength Calculations for Beams

A strip of plating equal to 30 $t$, where $t$ = thickness of plating, should be included and the beams regarded as fixed. Let $l$ = unsupported section of the beam, $w$ = load per unit of length, $S$ = the section modulus. Then the maximum stress, $p$, will occur at the points of supports, and will be equal to $\frac{wl^2}{12S}$. For a given unit-load and given allowable stress, the section modulus is proportional to the square of the unsupported length of the beam. Or with a given beam and an assumed standard



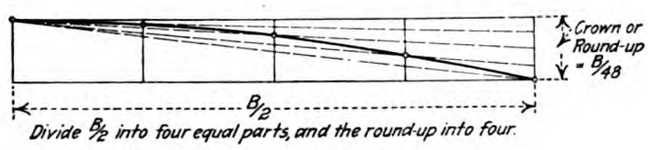

INFLUENCE-LINES FOR LONGITUDINAL BEAMS

load there must be a certain maximum spacing of pillars or other points of support. This rule is adopted for all vessels.

Example No. 1. The deck of a ship is built of 10-in., 21.8-lb. channels, spaced 4 ft. apart and covered with $\frac{1}{2}$-in. plating. Uniform load is 300 lb. per square foot. Allowable stress is 7 tons per square inch. Find the maximum spacing of the supports.

$$w = \frac{4 \times 300}{2240 \times 12} = \frac{10}{224} \text{ tons per inch.}$$

Including in the effective section of the beam a strip of plating $30 \times \frac{1}{2}$ in. $S = 23.8$, $l = \frac{12Sp}{w} = \frac{12 \times 23.8 \times 7 \times 22.4}{144} = 311$, and $l = 17.6$ ft. If the strip of plating be reckoned at 50 $t$, or 25 in. wide. $S = 24.5$ and $l = 17.9$.




METHOD OF CONSTRUCTING CURVE OF DECK

Example No. 2. Using Lloyds' tables, consider a beam 76 ft. long, supported by three pillars. The scantlings required are $3\frac{1}{2}$ by $3\frac{1}{2}$ by 10 in. channels, 0.50 web, and 0.575 flange, spaced 30 in. centre to centre, with $\frac{1}{2}$-in. deck-plating. Cargo at 40 cu. ft. per ton is stored 7 ft. 6 in. high on the deck = 420 lb. per square foot. The maximum stress in the beam if $l = 19$ ft., $w = \frac{2.5 \times 7.5}{40 \times 12} = 0.39$ ton per inch. $S$, including 15 in. of plating, equals 30.5

$$p = \frac{0.039 \times 19 \times 19 \times 12 \times 12}{12 \times 30.5} = 5.5 \text{ tons per sq. in.}$$

The beams should be the same depth throughout.

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### Standard Strength Calculations

Dimensions of ship, 28 ft. 3 in. by 40 by 290 ft.

Displacement, 5700 tons.

Draft (mean), 23 ft. 6 inches in still water.

Cargo in, fuel out.

Vessel on crest of wave, length 290 ft., height 14 ft. 6 in.

Maximum bending-moment, 54,000 foot-tons $= \frac{WL}{32}$.

### Stresses from Hogging

Top in tension. Upper deck, $p = \frac{My_1}{I} = \frac{54000 \times 13.8}{95000}$ $= 7.85$ tons per square inch.

Bottom in compression. Keel, $p = \frac{My_2}{I} = \frac{54000 \times 11.65}{1275315}$ $= 0.495$ tons per square inch.

Cargo out, fuel in.

Displacement, 2900 tons.

Vessel in wave-hollow. Length 290 ft., height 14 ft. 6 in.

Maximum bending-moment, 35,000 foot-tons $= \frac{WL}{24}$.

### Stresses from Sagging

Top in compression. Upper deck, $p = \frac{My_1}{I} = \frac{35000 \times 16.6}{1275315} = 0.456$ tons per square inch.

Bottom in tension, Keel, $p = \frac{My_2}{I} = \frac{35000 \times 14.6}{95000}$ $= 5.4$ tons per square inch.

### Centre of Gravity of Ship

| | | Moments taken from keel | | Moments taken from middle of length | | | |
|---|---|---|---|---|---|---|---|
| | | | | Before | | Abaft | |
| Equipment | Tons | Lever-arm | Moment | Lever-arm | Moment | Lever-arm | Moment |
| Water ..... | 50 | 20 | 1,000 | 135 | 6,750 | ... | ..... |
| Stores ..... | 50 | 30 | 1,500 | ... | .... | 125 | 6,250 |
| Fuel ..... | 300 | 16 | 4,800 | 5 | 1,500 | ... | ..... |
| Guns ..... | 7 | 32 | 224 | 130 | 455 | 130 | 455 |
| Anchors ..... | 31 | 28 | 868 | 125 | 3,875 | ... | ..... |
| Masts, yards, etc. | 28 | 70 | 1,960 | 65 | 910 | 70 | 980 |
| Machinery .... | 360 | 16 | 5,760 | ... | .... | 12.5 | 4,500 |
| Hull, concrete.. | 1734 | 11.65 | 20,100 | ... | .... | 7 | 12,200 |
| Hull, steel..... | 340 | 13.65 | 4,650 | ... | .... | 7 | 2,380 |
| Homogeneous .. | 1800 | 16 | 28,800 | 62.5 | 112,500 | ... | ..... |
| Cargo ..... | 1300 | 16.5 | 21,400 | ... | .... | 75 | 97,500 |
| Total ..... | 6000 | | 91,062 | | 125,990 | | 124,765 |

$\frac{91062}{6000} = 15.2$ ft., distance of centre of gravity above top of keel.

$125{,}990 - 124{,}765 = 1225$.

$\frac{1225}{6000} = 2.5$ in., distance of centre of gravity in front of mid length.

$\frac{40862}{2900} = 14.1$ ft., distance of centre of gravity above keel with ship light and fuel, water, and stores on board.

$\frac{33562}{2500} = 13.3$ ft., distance of centre of gravity above keel, ship light, fuel, water, and stores not on board.

Moment of statical stability or $GZ = GM \sin \Theta + \frac{BM}{2}$ tan sin $\Theta$ = arm of righting level. Where $\Theta = 30°$ $GZ = 3.05 \times 0.5 \frac{5.75 \times 0.577 \times 0.5}{2} = 2.355$.

$W \times GZ = 6000 \times 2.355 = 14{,}200$ foot-tons.

For a rectangular vessel,

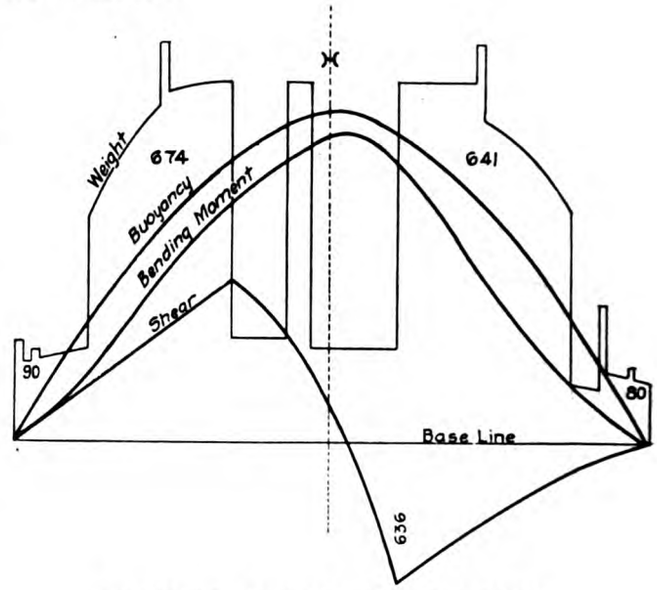
Transverse $BM = \frac{B}{12d}$

Longitudinal $BM = \frac{L}{12d}$

Height of $B = \frac{d}{2}$

If G is at a height of $\frac{d}{2} + \frac{B}{12d}$, the vessel will be in neutral equilibrium transversely.

If $G$ is at a height greater than $\frac{d}{2} + \frac{B}{12d}$, the vessel will be unstable.




STRENGTH-CURVES FOR PROPOSED VESSEL

If $G$ is at a height less than $\frac{d}{2} + \frac{B}{12d}$, the vessel will be stable.

If the vessel is homogeneous the height of G $= \frac{d}{2}$.

Trim is used to designate the draft fore and aft at which the vessel is floating. If the draft forward is 9 ft. and the draft aft 10 ft., the trim is said to be 1 ft. by the stern. 'Trimmed by the head' means that the draft forward was the greatest. If drafts are equal, the vessel is said to be floating on an even keel. The moment to change trim is expressed by the formula,

$$\text{Moment} = \frac{\text{displacement} \times \text{longitudinal bending moment}}{12 \times \text{length of ship}}$$

Longitudinal bending-moment $= 0.0735 \times \frac{AL}{BV} = \frac{0.0735 \times 10208 \times 10208 \times 290}{40 \times 210000} = 267$ ft.

Moment to change trim one inch $\frac{6000 \times 267}{12 \times 290} = 460$ ft.-tons.

### Principal Stresses and Maximum Shearing Stress

The case of most practical interest in ship construction is when a simple direct stress, $p$, generally caused by bending, acts in conjunction with a shearing force, $q$. The principal stresses are here found by the formula, $a = \frac{1}{2}(p \pm \sqrt{p^2 + 4q^2})$. The angle at which these stresses act may be obtained from the formula, tan $2\Theta = \pm \frac{2q}{p}$. The principal stresses act at right angles to each other, except at the neutral axis, where $p = 0$ and $a =$

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$\pm q_o$. The maximum shearing stress at any point is given by the formula, $b = \frac{1}{2}\sqrt{p^2 + 4q^2}$, which determines two equal stresses acting at right angles to each other and always at an angle of 45° with the principal stresses. At the neutral axis, $p = 0$. The maximum shearing stress, $b = q_o$, and acts horizontally and vertically. Each of the principal stresses produces a strain $e$ in its own direction, and at the same time a lateral stress at right angles to itself, of opposite sign and equal to $\frac{e}{m}$, where $m$ is a factor depending on the elastic properties of the material. Since the two principal stresses are of opposite sign, the strain that each produces will be augmented by the lateral strain produced by the other. The resulting compound strains, $e$, are determined by the formula, $Ee = \frac{m-1}{2m}\ p \pm \frac{m+1}{2m}\sqrt{p^2 + 4q^2}$.

For ship-building steel $m = \frac{10}{3}$.

At the neutral axis, the virtual stresses will be $\pm 1.3q$.

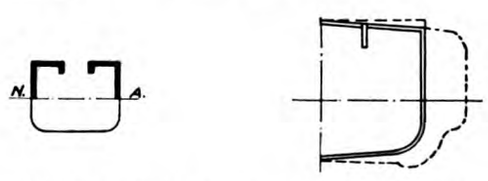
When $m = \frac{10}{3}$, $Ee = 0.35p \pm 0.65\sqrt{p^2 + 4q^2}$.

To the strains so produced, correspond fictitious simple stresses of magnitude $Ee$, called virtual principal stresses.

### Shearing Stress for Comparison with Other Ships

*a.* Maximum shearing force forward = 580 tons.
*b.* Maximum shearing force aft = 680 tons.
*c.* $a$ divided by displacement = 0.097.
*d.* $b$ divided by displacement = 0.113.
*e.* Section $a$ from stem = 40%.
*f.* Section $b$ from rudder-post = 34%.
*g.* Mean shearing-stress in concrete $\frac{680}{7910 + 1150}$ = 0.075 = 176 lb. per square inch.
*h.* Maximum shearing-stress in steel $\frac{680}{553} = 1.28$ = 2850 lb. per square inch.
*i.* Maximum shearing-stress in concrete = 0.175 = 392 lb. per square inch.
*j.* Maximum shearing-stress in steel = 5.5 = 12,250 lb. per square inch.
*k.* Thickness of concrete in way of $i$ = 6 in.
*l.* Reinforcement in way of $i$ = 0.235 sq. in.
*o.* $\frac{\text{Maximum shearing stress in concrete}}{\text{Mean shearing stress in concrete}} = \frac{i}{g} = \frac{0.175}{0.075} = 2.34$.
*p.* $\frac{\text{Maximum shearing stress in steel}}{\text{Mean shearing stress in steel}} = \frac{j}{h} = \frac{5.50}{1.28} = 4.3$.

Dimensions, 28 ft. 3 in. by 40 ft. by 290 ft.
Total area steel section = 553 sq. in.
Total area concrete section = 7910 + 1150 = 9060 sq. in.
Total shearing-force = 680 tons.




PART CONSIDERED IN SHEAR AND ACTION OF SHEAR

### Strength-Curves

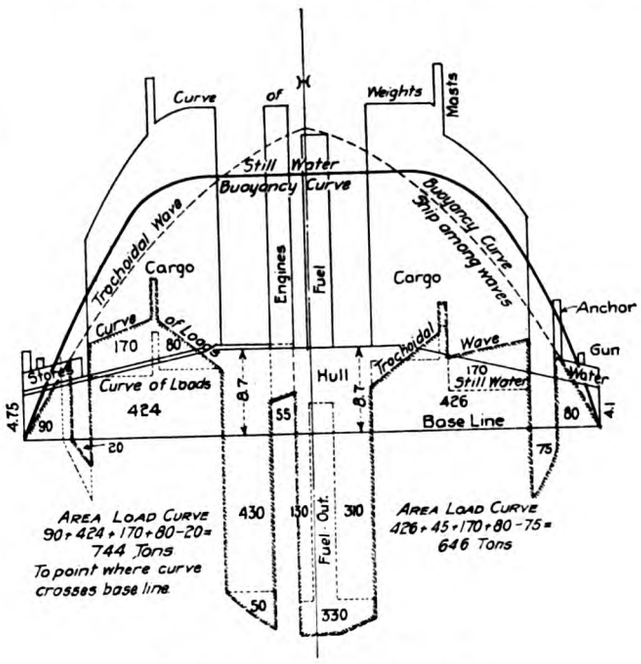
The total weight of hull equals $H$ tons. Divide the base, $L$, into three equal parts.

Then $\frac{0.566H}{L}$ = forward ordinate. $\frac{0.566 \times 2100}{290} = 4.1$

$\frac{1.195H}{L}$ = middle ordinate. $\frac{1.195 \times 2100}{290} = 8.7$

$\frac{0.653H}{L}$ = aft ordinate. $\frac{0.653 \times 2100}{290} = 4.75$

This gives outline of the hull on the diagram. Add machinery, shafting, propellers, guns, cargo, stores, etc., to complete the weight-curve. The curve of buoyancy is equal to the cubic contents of the hull divided by 35 and is a fair curve. Figure the area of each frame-space and divide by 35 for the ordinate in tons per linear foot. The area of the bouyancy-curve equals the area of the weight-curve and each shows the weight per linear foot. Each curve represents the total weight of the ship, which




CURVES FOR PROPOSED VESSEL

is equal to the displacement, $W$. Another condition of equilibrium is that the centre of gravity of the weight and the centre of gravity of the water displaced are in the same vertical line and the same position fore and aft. The curve of loads is the difference between the bouyancy and the weight curves at various points, and the area below the base-line must balance the area above it, since the area of the two curves being equal, their differences must be equal.

Shear-curve = area load-curve to point where load-curve crosses base-line = 744 tons, maximum.

Bending moment = area of shear-curve up to crossing of base-line = $\frac{744 \times 160}{2}$ = 59,500 ft.-tons, maximum.

Maximum shear aft = 744 tons, less 15% reduction for wave-pressure = 650 tons.

Maximum bending-moment = 59,500 less 12% for cor-

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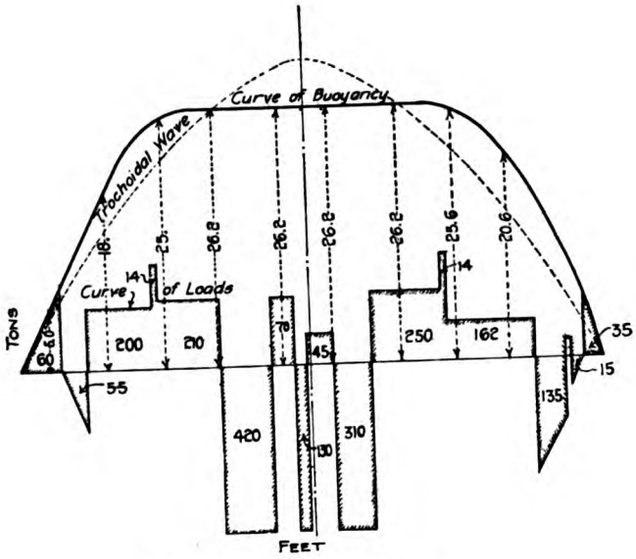
rected wave-pressures = 54,000 for hogging. The maximum bending-moment for sagging is about $\frac{2}{3}$ of this.




CURVES OF BUOYANCY AND LOAD

### Bending-Moment and Shear

The dead rise will be 9 in., and the molded breadth 40 ft. The molded depth is 28 ft. 3 in. from top of keel to top of deck at side. Round of beam = camber = $\frac{B}{48}$ = 10 in.

Depth of hold is 24 ft. 3 in. Length between perpendiculars, 280 ft.

Length over all, 290 ft.

Height of hatch coaming, 24 in.

Freeboard, 4 ft. 9 in.

Bending moment due to 'hogging' at middle of ship = $\frac{LW}{35} = \frac{280 \times 6000}{35} = 48{,}000$ foot-tons.

Shear at quarter-points = $\frac{6000}{8} = 750$ tons.

### Floors

Buoyancy per sq. ft. on floors = $\frac{h}{35}$

$\left(\frac{\text{Half-weight of hull}}{0.78\ LB}\right) = \frac{14.5}{35} = \frac{1250}{8700} = 0.145 = 0.270$ tons.

$h$ = light draft = 42% of loaded draft + 4.5 ft. freeboard = $(0.42 \times 23.6) + 4.6 = 14.5$ ft.

Area of load-water line = $280 \times 40 \times 0.78 = 8700$ sq. ft. Half weight of hull = $\frac{2500}{2} = 1250$ tons.

Bouyancy in tons per sq. ft. = 0.27.

Bouyancy in pounds per sq. ft. = $0.27 \times 2240 = 600$ lb. = $w$.

Floors spaced 5 ft. centre to centre = $S$.

Bending moment =

$$\frac{SwB^2}{12} = \frac{5 \times 600 \times 40 \times 40}{12} = 400{,}000 \text{ ft.-lb.}$$

Shear = $\frac{SwB}{2} = \frac{5 \times 600 \times 38}{2} = 57{,}000$ lb.

$F_c$ = 1000 lb. per sq. in.

Shearing stress for concrete = 400 lb. per sq. in., when in excess of 100 lb. all to be carried by steel.

For the concrete ship, the load is taken as 448 lb. per sq. ft.

The load on the transverse beams is $\frac{5 \times 448}{2240 \times 12} = \frac{1875}{22400}$ tons per sq. in. $S = \frac{wl}{12p} = \frac{1875 \times 13 \times 13 \times 12 \times 12}{12 \times 22400 \times 5.5}$ = 29.5 This corresponds to a 10-in. 35-lb. I-beam with a bending moment of 39,000 ft.-lb.

$\frac{wl^2}{10} = 39{,}000$. $w = \frac{10 \times 39000}{13 \times 13} = 2300$ lb. Select a 4 by 18 in. beam.

$A_s = \frac{39000 \times 12}{16000 \times 0.875 \times 16} = 2.1$ sq. in. at supports.

For a cantilever beam, $w = \frac{13.5 \times 448}{2240 \times 12} = \frac{505}{2240}$

$S = \frac{505 \times 40 \times 40 \times 12 \times 12}{12 \times 2240 \times 5.5} = 790.$

Corresponding to a plate-girder composed of $\frac{1}{2}$ by 48 in. plate with four $\frac{5}{8}$ by 6 by 6 in. angles, weighing 178.4 lb. per lin. ft. The bending moment is 9.850,000 in.-lb. at support.

$\frac{9850000}{0.875 \times 16000 \times 62} = 11.4$ sq. in. = $A_s$.

At the centre, $d$ = 31 in.

### Column-Curves

Eccentrically-loaded column.

Given load = 15.5 tons, length = 97.5 in., fixed ends.

$\frac{l}{2r} = 29.7$ $r = 1.64$.

$A = 5.45$ sq. in.

$f = 60{,}000 = 28.6$ tons per sq. in.

From curve, $p$ = 35,000 lb. per sq. in. = 15.8 tons per sq. in.

Factor of safety = $\frac{5.45 \times 15.8}{15.5} = 5.6$.

Assume same load and $e$ = 2.32 in.

Let $E$ = 13,500 tons per sq. in.

$\frac{y}{r} = \frac{2.5 \times 2.32}{1.64 \times 1.64} = 2.16$.

$$(29.7 \times 29.7) = \frac{9.6 \times 13500(26.8 - p \times 1.6 \times 2.16)}{p\left[26.8 + p\left(\frac{2.16}{5} - 0.88\right)\right]}$$

This gives the quadratic equation,

$$p^2 - 1293\,p + 8790 = 0.$$

$p$ = 6.8 tons per sq. in.

$f = \frac{5.45 \times 6.8}{15.5} = 2.4$.

Assume the column to be pin-ended, the length being 91 in. between pins. $\frac{l}{r} = \frac{91}{1.64} = 55.5$.

From the column-curves, $p$ = 30,700 lb. per sq. in. = 13.7 tons.

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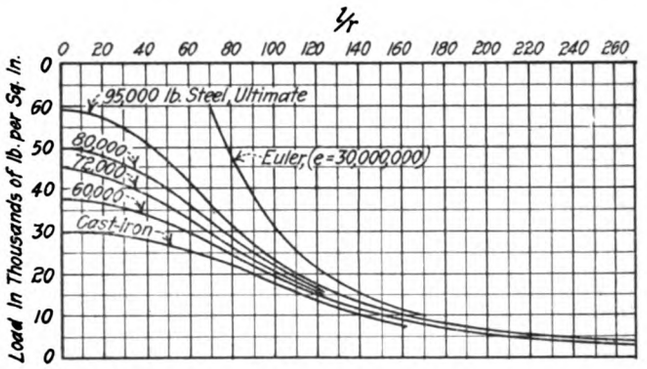
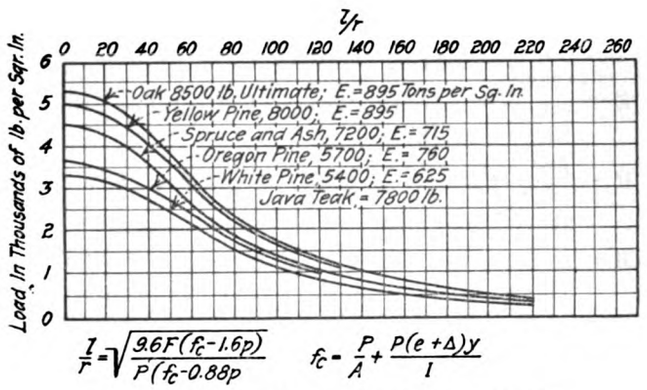




l/r
Load in Thousands of lb. per Sq. In.
Oak 8500 lb. Ultimate; E.=895 Tons per Sq. In.
Yellow Pine, 8000; E.=895
Spruce and Ash, 7200; E.=715
Oregon Pine, 5700; E.=760
White Pine, 5400; E.=625
Java Teak = 7800 lb.

$$\frac{l}{r}=\sqrt{\frac{9.6F(f_c-1.6p)}{P(f_c-0.88p}} \qquad f_c=\frac{P}{A}+\frac{P(e+\Delta)y}{I}$$

CURVES FOR METAL AND WOODEN COLUMNS

Factor of safety $=\frac{5.45\times 13.7}{15.5}=4.8$ or twice that of the eccentrically loaded column.

## Plating

Thickness of slab in inches $=\frac{l(4w+2800)}{10000}$, where

$l$ = span in feet.

$w$ = load in pounds per square foot.

Percentage of steel $=\frac{w l^2}{f_s(0.9)bd^2}$, where

$f_s$ = unit stress in steel.

$b$ = width of slab.

$d$ = depth to steel.

Maximum width of steel plating $= 80\ t$, where $t=$ thickness.

One square inch of steel is equal in compression to a 4 by 4 in. douglas fir timber, or to 25 sq. in. of wood in tension.

For a steel ship, the frame spacing in inches, $s = 0.025L + 17$, where $L$ = length from stem to rudder-post, provided length exceeds 160 ft. The minimum spacing is 21 in.

Thickness of side-plating, $t=\frac{Fm}{Iq}=0.105L+17$, expressed in hundredths of an inch, where

$F$ = maximum shearing force at the section.

$q$ = shearing stress at the neutral axis.

$m = \frac{1}{2}$ total moment of longitudinal members $= dA$.

$I$ = moment of inertia $= d^2A$.

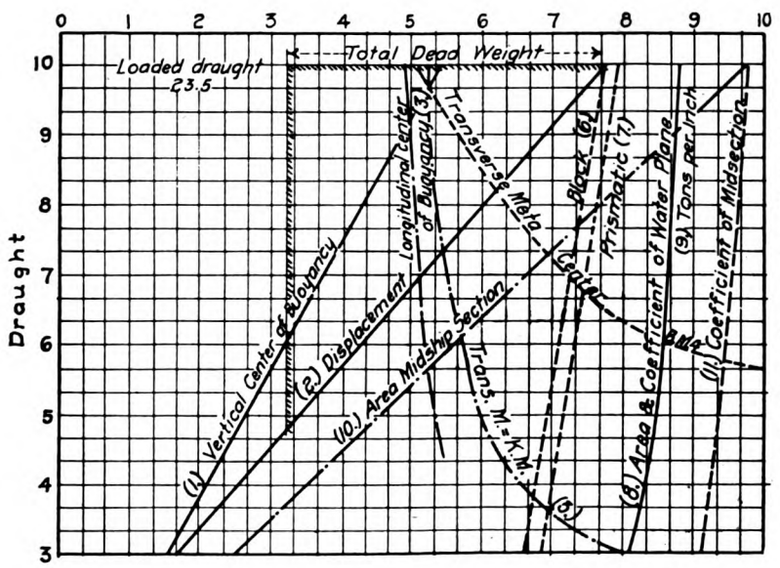
$V=\frac{LBd}{350}$, where $L$ = length, $B$ = breadth, and $d$ = draft. Block = 0.8.

$B=\frac{L}{10}+10$.

| Number of ordinate. | Position of ordinates from middle of base in fractions of half lengths of base. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | 0.5773 | | | | |
| 3 | | | | 0 | | 0.7071 | | | |
| 4 | | | | 0.1876 | | 0.7947 | | | |
| 5 | | | 0 | | 0.3745 | | 0.8325 | | |
| 6 | | | 0.2666 | | 0.4225 | | 0.8662 | | |
| 7 | | 0 | | 0.3239 | | 0.5297 | | 0.8839 | |
| 8 | | 0.126 | | 0.4062 | | 0.5938 | | 0.8974 | |
| 9 | 0 | | 0.1679 | | 0.5288 | | 0.6010 | | 0.9116 |
| 10 | 0.0838 | | 0.3127 | | 0.5000 | | 0.6873 | | 0.9162 |

TCHEBYCHEFF'S RULE FOR BUOYANCY

Application of rule to area-of-buoyancy curve, using 10 ordinates forward and aft of the midsection. Using 145 ft. for the half-length of the base, the ordinates ac-




SCALES

Vertical 0 1/4" 1/2" 1 = d/10 = 2.35

Horizontal

(1.) 0 1/4" 1/2" 1 = d/10 = 2.35

(2.) " = LBd/350

(3.) " = L/100

(4.) " = B²/60d

(5.) " = d/10 + B²/60d

(6.) " = 0.1 of Coefficient, i.e. LBd/350

(7.) " = 0.1 of Coefficient, i.e. Midsection Area × L/350

(8.) " = LB/10

(9.) " = LB/10×420

(10.) " = BD/10

(11.) " = 0.1 of Coefficient LB/10

STANDARD CUBVES FOR VESSEL

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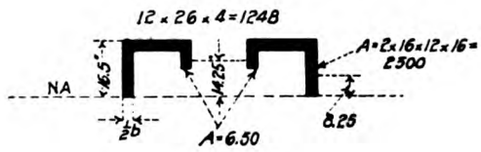
cording to the table are as follows: 12, 46, 72.5, 100, and 132, respectively. The ordinates are, beginning at the forward end: 8.5, 20.6, 25.2, 26.2, 26.2, 26.2, 26.2, 25, 18, and 6. These ordinates are added together, the sum multiplied by the length, and the product divided by the number of ordinates to get the area.

$\frac{208 \times 290}{10} = 6000.$

### Shear Calculations




$\text{Shear} = q = \frac{Fm}{12Ib}$

To compute $m$

| | | |
|---|---|---|
| $136 \times$ | $2.35 =$ | 320 |
| $1248 \times$ | $16.85 =$ | 21,000 |
| $648 \times$ | $15.35 =$ | 10,000 |
| $1450 \times$ | $8.2 =$ | 11,850 |
| | | 43,170 $= m$ |

Assume $\frac{1}{2}b = 4$ in.

$\frac{500 \times 43170}{2 \times 4 \times 1275315 \times 12} = 0.178$ tons $= 400$ lb.

Assume $\frac{1}{2}b = 5$ in. Add to $m$, $362.5 \times 8.2 =$ 2.965

43,170

46,135

$1.275315 + 0.02655 = 1.301865$

$\frac{600 \times 46135}{2 \times 5 \times 1.301865 \times 12} = 0.178$ ton $= 400$ lb.

Assume $\frac{1}{2}b = 6$ in. Add 2965 to $m$ as before.

$\frac{690 \times 49100}{2 \times 6 \times 1.328415 \times 12} = 0.178$ ton $= 400$ lb.

Pitching increases the bending moment considerably at the quarter-points. Heaving may increase the bending moment as much as 15% amidships. Waves may vary in length from 180 to 450 ft. The height of waves may be assumed at 10 ft. for a stiff breeze, 15 ft. for a gale, 20 ft. for a strong gale, and 28 ft. for a hurricane. Where a ship is inclined 30° to the vertical, the shearing stresses are increased 5% over the corrected wave-shear and the bending moment 3%. If when using the trochoidal wave, the bouyancy-curve is less or greater than the weight, the amount the curve must be raised or lowered is given by $\frac{W - W_1}{t}$ = amount in inches, where

$W$ = weight of ship.

$W_1$ = displacement of bouyancy.

$t$ = tons per inch of wave water-line $= \frac{AWL}{35 \times 12} = \frac{10208}{420} = 24.3$ tons.

### Metacentric Height

$n = \text{Block} = abc = \frac{6000 \times 35}{290 \times 40 \times 23.5} = 0.77.$

$b$ = midship section $= \frac{n}{ae} = 0.975$ $\frac{HA}{Bd} = 40 \times 23.5 \times 0.975 = 916$ sq. ft.

$a$ = load water-line $= \frac{n}{be} = 0.88$ $\frac{p}{e} = 290 \times 40 \times \times 0.88 = 10{,}208$ sq. ft. $= AWL$.

$p$ = prismatic $= \frac{n}{b} = 0.79$.

$e$ = relation $= \frac{p}{a} = 0.90$.

$i$ = inertia water-plane $= 0.065$.

$CB$ = centre of bouyancy $= \frac{d(5a - 2n)}{6a} = \frac{23.5 \times (5 \times 0.88 - 2 \times 0.77)}{6 \times 0.88} = 12.7.$

$M$ = Morish rule $= \frac{d}{2} + \frac{V}{AWL} = \frac{23.5}{2} + 5.75 = 17.5.$

$BM$ = transverse metacentre $= \frac{I}{n}(0.845) = \frac{I}{V} = \frac{1203500}{210000} = 5.75 = \frac{B^2M}{d}$

$CG$ = centre of gravity above keel of equipped ship $= 15.2 = 0.54D$.

$M = \frac{B^2M}{d}$. $CB = \frac{40 \times 40 \times 0.0845}{23.5}$ 12.5 = 18.25 ft. above keel.

$GM$ = metacentric height = 18.25 − 15.2 = 3.05 ft. This varies in cargo-ships from one to three feet.

### Coefficients

$\frac{6000 \times 35}{280 \times 40 \times 2.5} = 0.798.$

$\text{Block} = \frac{V}{LBd} = abe = \frac{6000 \times 35}{280 \times 40 \times 2.5} = 0.798.$

$\text{Midship section} = b = \frac{Z}{ae} = 0.97.$

$\text{Load water-line} = a - \frac{Z}{be} = 0.87.$

$\text{Prismatic} = p \times \frac{Z}{b} = 0.82.$

$\text{Relation} = e \times \frac{p}{a} = 0.95.$

$\text{Bilge diagonal} = \frac{p}{96} = 0.85.$

Inertia of water-plane $= i = 0.69$.

$D$ = distance from top of keel to main deck = 28 ft.

$G$ = distance, centre of gravity above keel of equipped ship $= 0.535\ D = 15$ ft.

Centre of bouyancy $= CB = \frac{d(5a - 2Z)}{6a} = 0.51 \times 23.5 = 12$ ft. distance above keel.

$CB$ (Morish rule $= \frac{1}{3}\left(\frac{d}{2} + \frac{V}{AWL}\right) = \frac{1}{3}\left(\frac{23.5}{2} - \frac{210000}{9720}\right) = 11.08.$

23.5 − 11.08 = 12.42 ft. distance above keel.

$280 \times 40 \times 0.87 = 9720 = AWL$.

$V = W \times 35 = 6000 \times 35 = 210{,}000$.

$W$ = displacement = 6000 tons.

$V$ = volume $= W \times 35 = 210{,}000$ cu. ft.

$LB^3i = I = 290 \times 40 \times 40 \times 40 \times 0.65 = 1{,}203{,}500$.

$f_s$ = 16,000 lb. per sq. in. and 20,000 lb. per sq. in. for bulkheads.

All steel bars to be square and deformed.

Assume 7 in. width of stem and 300 lb. shear.

$\frac{57000}{7} = 8140.$ $\frac{8140}{260} = 31.5$ in.

Use a 7 by 34 in. beam.

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Comparison of a 3500-ton concrete ship with the standard modern wooden ship of the U. S. Shipping Board, single-deck type.

| | Wood | Concrete |
|---|---|---|
| Length over all, feet | 286 | 290 |
| Length between perpendiculars (L), feet | 276 | 280 |
| Beam over plating (B), feet | 46 | 40 |
| Depth molded at side (D) feet | 26 | 28 |
| Number of water-tight bulkheads | 4 | 6 |
| Local draft, feet | 23.5 | 23.5 |
| Total estimated deadweight tonnage | 3500 | 3500 |
| Sea-speed, loaded, knots | 10 | 10 |
| Indicated horse-power | 1400 | 1400 |
| Concrete in hull, cu. yd | ... | 950 |
| Concrete in hull, tons | ... | 1630 |
| Wood in hull (douglas fir), tons | 1827 | 100 |
| Reinforcing-steel and fastenings, tons | 146 | 340 |
| Anchors and cables, tons | 31 | 31 |
| Paint and caulking, tons | 10 | 4 |
| Forgings and castings, tons | 35 | 35 |
| Hull piping and machinery, tons | 50 | 50 |
| Two guns, tons | 7 | 7 |
| Miscellaneous outfit, tons | 28 | 28 |
| Total hull-weight, tons | 2134 | 2225 |
| Propelling machinery, tons | 275 | 275 |
| Dead-weight, tons | 3500 | 3500 |
| Displacement, tons | 5909 | 6000 |
| Excess weight, concrete over wood, per cent | | 1½ |

## Floors

Bouyancy per square foot on floors =

$$\frac{h}{35} - \frac{\text{half-weight of hull}}{0.78LB} = \frac{14.5}{35} - \frac{1250}{8700} = 0.145 = 0.27 \text{ ton.}$$

$h$ = light draft = 42% of loaded draft plus 4.6 ft. of freeboard = $(0.42 \times 23.6) + 4.6 = 14.5$ ft.

Area of load water-line = $280 \times 40 \times 0.78 = 8700$ sq. ft. Half-weight of hull = 1250 tons.

Bouyancy in tons per square foot = 0.27=600 lb.=$W$.

Floors spaced 5 ft. centre to centre = $S$, bending moment = $\frac{SWB}{12} = \frac{5 \times 600 \times 40 \times 40}{12} = 400{,}000$ ft.-lb.

Shear = $\frac{SWB}{2} = \frac{5 \times 600 \times 38}{2} = 57{,}000$ lb.

$f_c$ = 1000 lb. per sq. in.

Shearing unit stress = 400 lb. per sq. in. When in excess of 100 lb. all to be carried by steel.

$f_s$ = 16,000 lb. per sq. in., in bulkheads, 20,000 lb.

All reinforcing bars used should be square and deformed.

Design for $\frac{7}{8}$ of 300 lb. for shearing stress and a 7-in. width of stem.

$\frac{57000}{260 \times 7} = 31\frac{1}{2}$ in.

Use a 7 by 34 in. beam.

$A_s = \frac{400000 \times 12}{16000 \times 0.875 \times 31.5} = 10.9$ sq. in.

Use nine $1\frac{1}{8}$-in. square bars with $\frac{1}{2}$-in. bars for stirrups.

Each stirrup is good for $4 \times 0.25 \times 16{,}000 = 16{,}000$ lb.

Spacing of stirrups = $\frac{16000 \times 0.875 \times 31.5}{57000} = 7.5$ in.

Use this spacing for $\frac{2}{3}$ of the distance and 16 in. for the middle third.

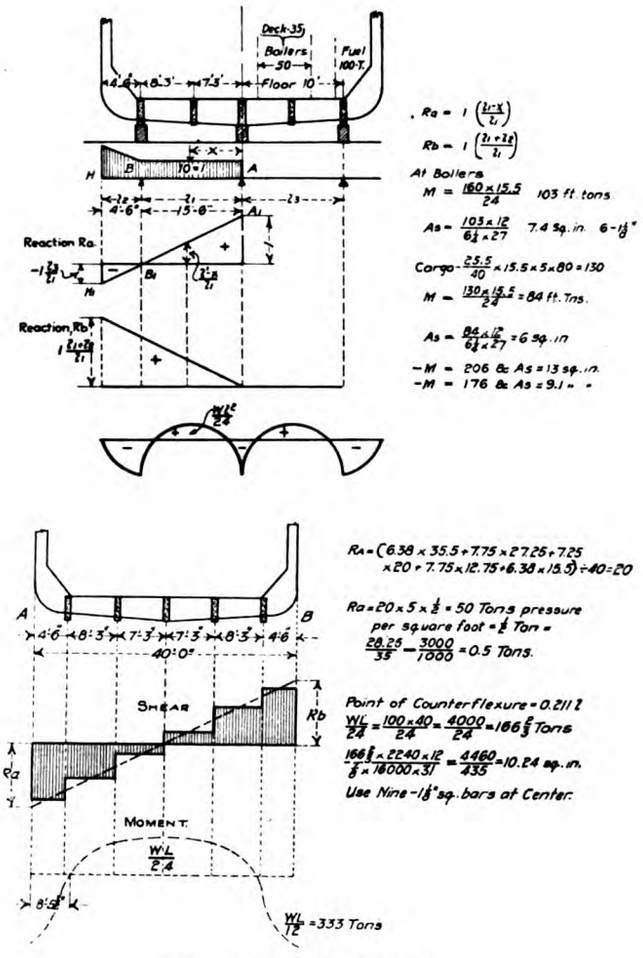
Bond = $\frac{57000}{0.875 \times 9 \times 4 \times 1.125 \times 31.5} = 52$ lb.

Tee. $\frac{400000 \times 12}{1000\left(1-\frac{5}{3}\times\frac{5}{31.5}\right)\left(5 \times 31.5\right)} = 43$ in.

$p = \frac{10.9}{425 \times 31.5} = 0.0083.$

$R = \frac{400000 \times 12}{42 \times 31.5 \times 31.5} = 114.$

For keel, use a 12 by 44 in. cantilever-beam, 30 in. at centre with nine $1\frac{1}{8}$-in. bars and $\frac{1}{2}$-in. stirrups spaced $7\frac{1}{2}$ in. centre to centre. For side-keelsons use a 9 by 40 in. beam, 27 in. at centre with six $1\frac{1}{8}$-in. bars and the same stirrups and spacing. For bilge-keelsons use a 9 by 36 in. beam, 27 in. at the centre with six $1\frac{1}{8}$-in. bars with the same stirrups and spacing. The maximum load in tons on the keels = $0.157\ bd$.


Deck-35
Boilers
50
Fuel
100 T.
Floor 10'
Reaction Ra
Reaction, Rb
At Boilers
M = 160 x 15.5 / 24 103 ft. tons
As = 103 x 12 / 6½ x 27 7.4 sq. in. 6-1⅛"
Cargo = 25.5/40 x 15.5 x 5 x 80 = 130
M = 130 x 15.5 / 2 = 84 ft. Tns.
As = 84 x 12 / 6½ x 27 = 6 sq. in
-M = 206 & As = 13 sq. in.
-M = 176 & As = 9.1 " "


SHEAR
MOMENT
Rb
Ra = (6.38 x 35.5 + 7.75 x 27.25 + 7.25 x 20 + 7.75 x 12.75 + 6.38 x 15.5) ÷ 40 = 20
Ra = 20 x 5 x ½ = 50 Tons pressure
per square foot = ½ Ton =
28.25/35 − 3000/1000 = 0.5 Tons.
Point of Counter Flexure = 0.211 l
WL/24 = 100 x 40 / 24 = 4000/24 = 166⅔ Tons
166⅔ x 2240 x 12 / ⅞ x 18000 x 31 = 4460/435 = 10.24 sq. in.
Use Nine -1⅛" sq. bars at Center.
WL/12 = 333 Tons

STRESS DIAGRAMS FOR FLOORS

## Concrete Hull

Area of wetted surface = $15.5\ WL = 15.5 \cdot 6000 \times 290$ = 20,500 sq. ft.

Area above load-water line = $2L$ (freeboard $\times$ 2.5) = $580 \times 7.25 = 4200$ sq. ft.

Deck = $0.9LB$ = 10,500 sq. ft.

Total area = $1.8L(B + D)$ = 35,200 sq. ft.

Bulkheads = 4000 sq. ft.

Total surface = 40,000 sq. ft.

$B + D$ = 68.25 ft. = framing number.

$L(B + D)$ = 19,700 sq. ft. = plating number.

## Frames

Frames are spaced same as floors, 60 in. centre to centre. Taking the section modulus from the load-line committee's table of standard strength of frames,

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$\frac{I}{y} = \frac{S(d-t)(f_1+f_2)}{1000} = \frac{60(23-3)(54+2)}{1000} = 67.$

The bending moment in in-lb. $= 67 \times 16{,}000 = 1{,}072{,}000$ in-lb. corresponding to a 15-in. 55-lb. I-beam.

Use an 8 by 21 in. concrete beam with seven $\frac{3}{4}$-in. bars.

$\frac{1070000}{0.875 \times 16000 \times 19} = 4$ sq. in.

Shear $= \frac{5l^2}{100} = \frac{5 \times 22 \times 22}{100} = 24$ tons. $\frac{24}{0.157} = 153$ sq. in. using $\frac{7}{8}$ of 400 lb. per sq. in. as a unit shearing stress.

$b = \frac{1070000}{1000(1-\frac{5}{3}\times\frac{5}{29})(5 \times 19)} = 20$ in.

$p = \frac{4}{20 \times 19} = 1.05\%.$

$R = \frac{1070000}{20 \times 19 \times 19} = 149.$

For stirrups use two $\frac{1}{2}$-in. bars at a stress of 8000 lb.

$\frac{8000 \times 0.875 \times 19}{24 \times 2240} = 2$ in. Use 2-in. spacing at bottom, increasing to 6 in. at the top.

Bond $= \frac{24 \times 2240}{0.875 \times 7 \times 3 \times 19.5} = 148$ lb.

### Turn of the Bilge

Shear $= \frac{5 \times 26 \times 26}{100} = 33.5$ tons. $BM = \frac{Sl^2}{70} = \frac{5 \times 26 \times 26 \times 26}{70} = 1250$ inch-tons.

Heel bracket at bilge to slope from bilge-keelson up the frame to a height equal to twice the depth of the floors at the keel.

1250 inch-tons $\times$ 2240 $= 2{,}800{,}000$ in.-lb.

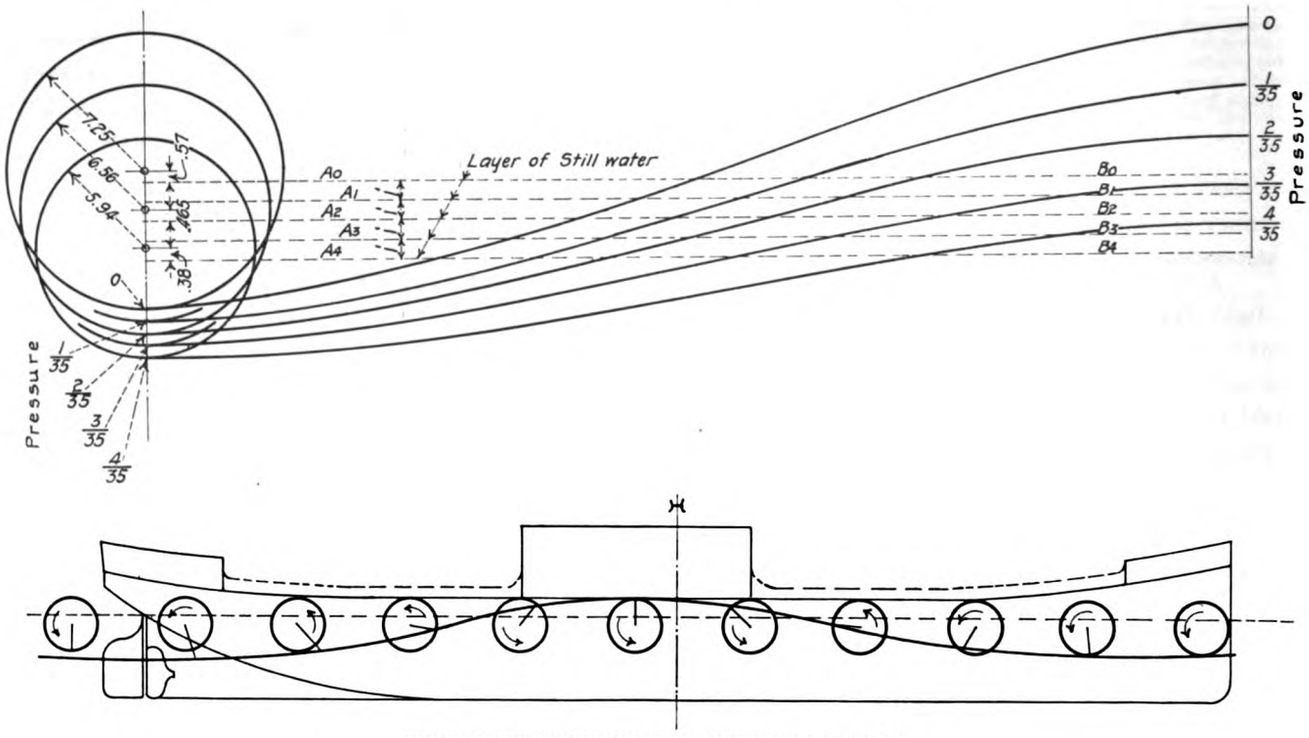
$\frac{2800000}{0.875 \times 36 \times 1600} = 5.5$ sq. in.

Shear $= 33.5 \times 2240 = 75{,}000$ lb.

$\frac{75000}{0.875 \times 36 \times 8} = 300$ lb. per square inch.

Use $\frac{1}{2}$-in. stirrup. Spacing $= \frac{0.875 \times 16000 \times 36}{75000} = 6.25$ in.

Bond $= \frac{75000}{0.875 \times 7 \times 4.5 \times 36} = 75$ lb.




CURVES FOR TROCHOIDAL-WAVE CALCULATIONS

TROCHOIDAL WAVE THEORY

rressures of Trochoidal equal to corresponding layers in still water.

FORMULAE

L = Length of ship. Distance between rolling circle center is same at 25ft.

Y = 1

r = Radius of tracing circle

$R = \frac{L}{2\pi}$ = Radius of rolling circle = 46 ft. $h = \frac{r^2}{2R}$

$r_0 = \frac{1}{10} = 7.25$ radius of surface tracing circle, $h_0 = \frac{\pi}{L} r_0^2 .010825 \times 7.25 \times 7.25 = .57$

Log. $r_1$ = Log. $\frac{1}{10} - \frac{2\pi}{L} = 6.9 = .86034 - .02165$. $h_1 = \frac{\pi}{L} r_1^2$ .51

" $r_2$ " " $-\frac{4\pi}{L} = 6.56$ $h_2 = \frac{\pi}{L} r_2^2$ .465

" $r_3$ " " $-\frac{6\pi}{L} = 6.24$ $h_3 = \frac{\pi}{L} r_3^2$ .42

" $r_4$ " " $-\frac{8\pi}{L} = 5.94$ $h_4 = \frac{\pi}{L} r_4^2$ .38

Ao Bo = Surface still water ao bo = Path tracing circle surface trochoid

A1 B1 = Horizontal layer still water at 1 ft. down. a1 b1 = " " " sub-surface

A2 B2 = " " " " 2 ft. " a2 b2 = " " " "

A3 B3 = " " " " 3 ft. " a3 b3 = " " " "

A4 B4 = " " " " 4 ft. " a4 b4 = " " " "

Total buoyancy equals weight of ship.

The resultant forces of buoyancy and weight act in same vertical lines.

### Results for Comparison with Other Ships

Description, single-deck cargo-steamer.

Material, reinforced concrete.

Dimensions, 28 ft. 3 in. by 40 by 290 ft.

Draft, 23 ft. 6 in.

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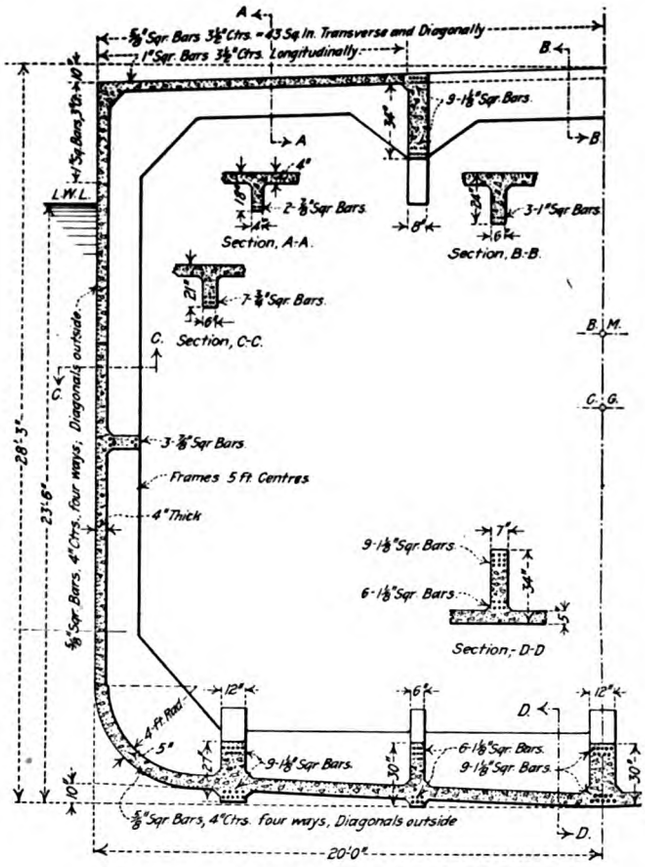
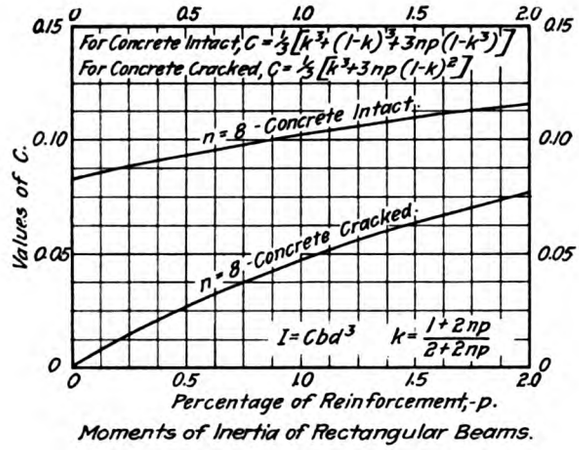
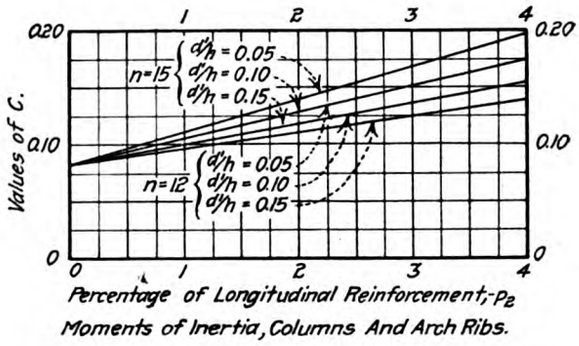



HALF SECTION OF VESSEL AMIDSHIPS


For Concrete Intact, C = 1/3 [k³ + (1-k)³ + 3np(1-k³)]
For Concrete Cracked, C = 1/3 [k³ + 3np(1-k)²]
n = 8 - Concrete Intact.
n = 8 - Concrete Cracked.
I = Cbd³ k = (1+2np)/(2+2np)
Values of C.
Percentage of Reinforcement, - p.
Moments of Inertia of Rectangular Beams.


n=15 d'/h = 0.05 d'/h = 0.10 d'/h = 0.15
n=12 d'/h = 0.05 d'/h = 0.10 d'/h = 0.15
Values of C.
Percentage of Longitudinal Reinforcement, - p₂
Moments of Inertia, Columns And Arch Ribs.

MOMENTS OF INERTIA OF RECTANGULAR BEAMS

Condition of loading, ship complete, cargo in, fuel out.

Position of section, amidships.

For hogging, the top is in tension and the bottom in compression.

For sagging, the top is in compression and the bottom in tension.

Area concrete above neutral axis, 3482 sq. in.

Area steel above neutral axis, 275 sq. in.

Area concrete below neutral axis, 4428 sq. in.

Area steel below neutral axis, 273 sq. in.

Total area concrete section, 7910 sq. in.

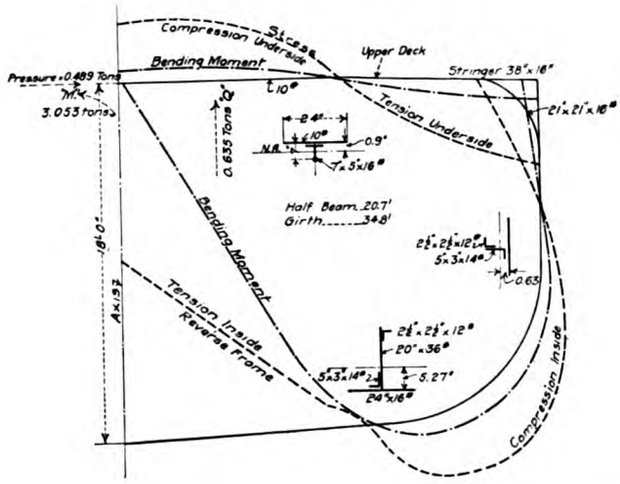
Total area steel section, 553 sq. in.

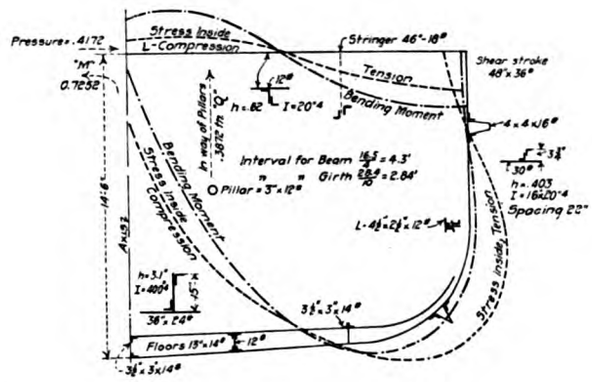
Moment of inertia, concrete section, 1,275,315.

Moment of inertia, steel section, 101,000.

Height of $I$ of concrete above keel, 11.65 ft.

Height of $I$ of steel above keel, 14.6 ft.



DR. BRUHN'S ELASTIC CURVES

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Ratio, $I$ of concrete to mid-depth, 0.415.

Ratio, $I$ of steel to mid-depth, 0.52.

Greatest distance of any particle above $NA$, concrete, 17 ft. 2 in.

Greatest distance of any particle below $NA$, concrete, 11 ft. 8 in.

### Moment of Inertia, Concrete Section

(Moments taken from top of keel, amidships)

| Item | Area Sq. In. | Lever-Arm Feet | Moment | Lever-Arm Feet | Moment of Inertia | $\frac{1}{12}Ah^2$ |
|---|---|---|---|---|---|---|
| 4-in. deck | 1248 | 28.5 | 35,500 | 28.5 | 1,045,000 | ..... |
| Girders | 648 | 27.0 | 17,500 | 27.0 | 472,000 | 157,000 |
| 4-in. sides | 2454 | 14.0 | 34,400 | 14.0 | 482,000 | 159,000 |
| Stringers | 136 | 14.0 | 1,900 | 14.0 | 26,600 | ..... |
| 5-in. bottom | 2220 | 0.5 | 1,110 | 0.5 | 555 | ..... |
| Girders | 1204 | 1.4 | 1,690 | 1.4 | 2,360 | 800 |
| Totals | 7910 | | 92,100 | | 2,028,515 | 316,800 |

$I + I_o = 2{,}028{,}515 + 316{,}800 = 2{,}345{,}315.$

Distance of centre of gravity above keel $= \frac{92100}{7910} =$ 11.65 ft.

$I$ about neutral axis =

$2{,}345{,}315 - (7910 \times 11.65 \times 11.65) = 1{,}275{,}315$

This is for 4-in. sides. For 6-in. sides add the following:

$$725 \times 8.2 \times 8.2 = 49{,}000$$
$$\frac{725 \times 8.2 \times 8.2}{12} = 4{,}100$$
$$1{,}328{,}415$$

To compute $m$ for concrete section, 6-in. sides

| | |
|---|---|
| $1248 \times 16.85 =$ | 21,000 |
| $648 \times 15.35 =$ | 10,000 |
| $1450 \times 8.2 =$ | 11,850 |
| $725 \times 8.2 =$ | 5,930 |
| $136 \times 2.35 =$ | 320 |
| 4207 | 49,100 |

$4207 - 725 = 3482$ sq. in. above neutral axis.

$$\frac{Fm}{Ib} = \frac{680 \times 49100}{2 \times 6 \times 1328415 \times 12} = 0.175 \text{ ton.}$$

$q = 0.175$ ton $= 392$ lb.

$F = 650 + 5\%$.

$$\frac{7910}{130.5 \times 12} = 5.05 \text{ in. per square foot.}$$

To compute $m$ for steel section

| | |
|---|---|
| $150 \times 15 =$ | 2250 |
| $82 \times 7.3 =$ | 598 |
| $23 \times 12.5 =$ | 287 |
| $5 \times 0.4 =$ | 2 |
| 260 | 3137 |

$$q = \frac{Fm}{Ib} = \frac{680 \times 3137}{12 \times 101000 \times 0.560} = \frac{2125000}{690000} = 3.13 \text{ tons}$$

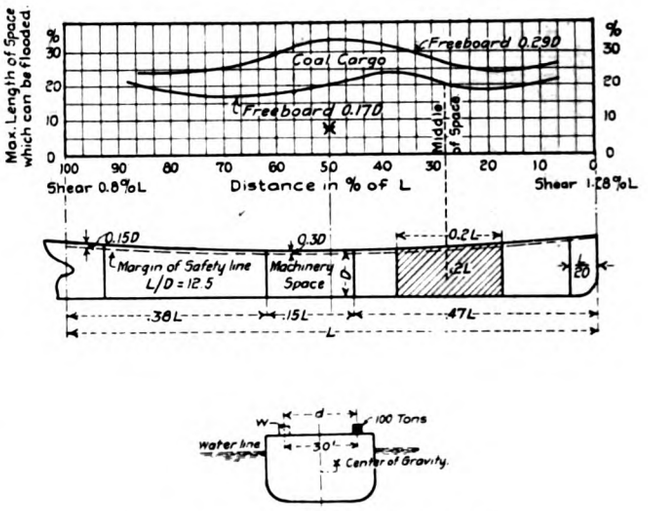
$$2b = \frac{82}{14.65} = 0.56$$

Average $F = \frac{680}{527} = 1.18$

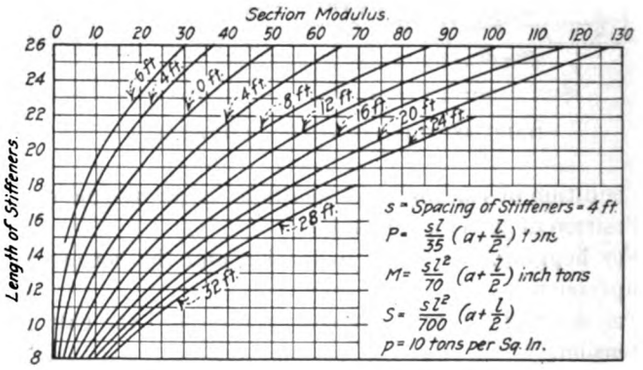
$$p = \frac{54000 \times 14.3}{101000} = 7.6 \text{ tons}$$

Ratio $= 2.63$

Use $\frac{5}{8}$-in. square bars, spaced 4 in. centre to centre, four ways, horizontal, vertical, and diagonal.

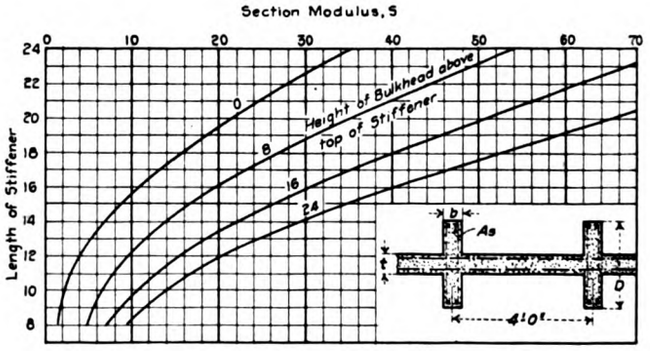



CURVES OF BULKHEAD SPACING




*Thickness of plating, lowest strake = $(6 + \frac{l+a}{4})$ lb. reduce 1 lb for each 6 ft. upwards; a = Head of water above to of stiffener; l = Length of stiffener; S = Section modulus = $\frac{I}{y}$; I = Moment of Inertia about neutral axis; y = distance of extreme fibre from neutral axis.*

BULKHEAD STIFFENERS (WARSHIPS)




BULKHEAD STIFFENERS (LLOYDS')

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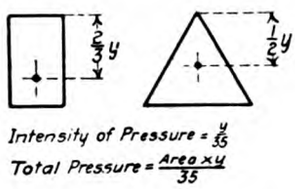
Maximum shearing force $= \frac{1}{2}\sqrt{p^2 + 4q^2} = \frac{9.8}{2} = 4.9$ tons per square inch.

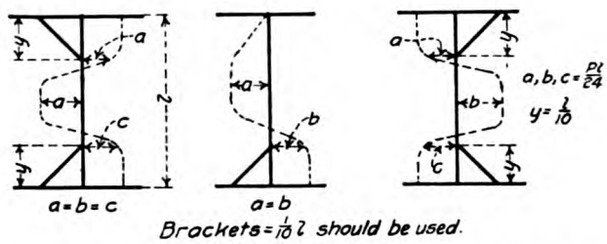
Virtual stress at $NA = 1.3 \times 3.1 = 4$ tons per square inch.

Compound stresses $= Ee = 0.35p \pm 0.65\sqrt{p^2 + 4q^2}$ $= 0.35 \times 7.65 \pm 0.65 \times 9.8 =$ approximately 9 tons at underside of deck at side.

## Bulkhead Calculations

| Distance ft | $b$, in. | $D$, in. | $A$, sq.in. | Slab, in. | Reinforcement diagonally and both ways | Weigh of pla.intg |
|---|---|---|---|---|---|---|
| 8 | 4 | .. | ... | 3 | ⅜-in. square bars, 6 in. centre to centre | 11 lb. |
| 12 | 4 | 10 | 0.88 | 3 | ⅜-in. bars, 4½ in. centre to centre | 12 lb. |
| 16 | 4 | 16 | 1.4 | 3 | ⅜-in. bars, 3½ in. centre to centre | 12.5 lb. |
| 20 | 5 | 20 | 2.0 | 4 | ⅜-in. bars, 4 in. centre to centre | 13 lb. |
| 24 | 7 | 20 | 3.5 | 4 | ⅜-in. bars, 3½ in. centre to centre | 14 lb. |
| 28 | 8 | 25 | 4.4 | 4 | ⅜-in. bars, 3 in. centre to centre | 15 lb. |
| 32 | 8 | 30 | 5.2 | 5 | ½-in. bars, 5 in. centre to centre | 16 lb. |




Plating assumed 30 in. centre to centre. Let $H =$ test head. $F =$ freeboard. $P =$ total load. $H - F = a$. $a - l =$ head at bottom. $s =$ distance between stiffeners. $a =$ head at top in feet. $d =$ draft. For collision bulkhead, $H = F$. Amidship, $H = \frac{d}{4}$.

At any point $H_x = \frac{d}{4} + \frac{2\left(F - \frac{d}{4}\right)x}{L}$ $L = 290$. $d = 23.5$ ft. $F$ at bow $= 4.75 + 3.75 = 8.5$ ft.

At 70 ft. forward, $H = \frac{23 - 5}{4} + \frac{2(8.5 - 5.9)70}{290} = 6.16$ ft. $P = \frac{sl^2}{35}(a + \frac{l}{2})$. $M = \frac{sl^2}{70}(a + \frac{l}{2})$. $S = \frac{sl^2}{700}(a + \frac{l}{2})$. $f_s = 10$ tons.

Pressure per square foot $= 0.5$ ton at 17.5 ft., and 1 ton at 35 ft.

## Moment of Inertia, Steel Section, Amidship

Moments taken from top of keel

| | Area, sq. in. | Lever-arm, ft. | Moment | Lever-arm, ft. | Moment of inertia | Ah |
|---|---|---|---|---|---|---|
| Deck ..... | 153 | 28.4 | 4330 | 28.4 | 122,000 | ..... |
| Top girders..... | 23 | 26 | 598 | 26 | 15,550 | 5,200 |
| Sheer-strake ..... | 24 | 26.7 | 640 | 26.7 | 17,100 | 6,400 |
| Bottom ..... | 150 | 0.5 | 75 | 0.5 | 37 | ..... |
| Sides ..... | 150 | 15 | 2250 | 15 | 33,750 | 11,250 |
| Stringer ..... | 5 | 14 | 70 | 14 | 980 | ..... |
| Bottom girders... | 49 | 2 | 98 | 2 | 196 | 66 |
| | 553 | | 3061 | | 189,613 | 22,916 |

$I + I_o = 189,613 + 22,916 = 212,529$.

Centre of gravity above top of keel $= \frac{8061}{553} = 14.6$.

$I$ about neutral axis $= 212,529 - (553 \times 14.6 \times 14.6)$ $= 95,000$.

$\frac{I}{y} = \frac{95000}{28.4 - 14.6} = 6900$.

$\frac{I}{y}$ for steel ship $= 7.3 \times 23.5 \times 40 = 6900$.

Longitudinal steel is equivalent to $\frac{553}{12 \times 116.5 \times 12} =$ 0.33 in. thickness of plate.

Area of steel in sides $= \frac{0.105L + 17}{10} = 4.75$ sq. in.

Use ⅞-in. square bars, spaced 4 in. centre to centre, four ways.

$m =$ statical moment.

To compute $m$, considering only the steel shown in the moment of inertia calculation:

| | | |
|---|---|---|
| 125 | $\times 13.8$ | $= 2100$ |
| 24 | $\times 12.15$ | $= 291$ |
| 77.5 | $\times 6.08$ | $= 470$ |
| 23 | $\times 11.4$ | $= 262$ |
| 276.5 | | 3123 |

Steel in sides $= \frac{2 \times 2.82}{12} = 0.47$.

$q = \frac{Fm}{Ib} = \frac{680 \times 3123}{12 \times 95000 \times 0.47} = \frac{2120000}{535000} = 3.95$ tons per square inch.

$p = \frac{54000 \times 13.4}{95000} = 7.6$ tons per square inch. $28 - 13.4 = 14.6$ ft.

Maximum shearing force $=$ $\frac{1}{2}\sqrt{p^2 + 4q^2} = \frac{1}{2}\sqrt{(7.6 \times 7.6) + (4 \times 3.95 \times 3.95)} =$ 5.5 tons per square inch.

Virtual stress at neutral axis $= 1.3 \times 3.95 = 5.13$ tons per square inch.

Compound stresses $= 0.35p \pm 0.65\sqrt{p^2 + q^2} =$ $(0.35 \times 7.6) \pm (0.65 \times 11) = 9.8$ tons per square inch at side under deck where 1-in. bars spaced 3 in. centre to centre are added.

## Change of Trim

Assuming $W$ as the displacement of a 6000-ton ship, then the weight of 100 tons is moved across the deck a distance of 30 ft. and vertically 6 ft. $\frac{1000 \times 30}{6000} = 0.5$ ft. $\frac{100 \times 6}{6000} = 0.1$ ft. The centre of gravity moves 0.5 ft. transversely and 0.1 ft. vertically.

In computing change of trim caused by opening a compartment to the sea, consider a rectangular lighter $100 \times 40 \times 10$ ft. with 3-ft. draft with a collision-bulkhead 6 ft. from the forward end.

Mean sinkage equals volume of lost buoyancy divided by area of intact water-plane $= \frac{40 \times 6 \times 3}{94 \times 40} = 2.25$ in.

$V = 100 \times 3 \times 40 = 12,000$. $W = \frac{100 \times 40 \times 3}{35} =$ 342 tons.

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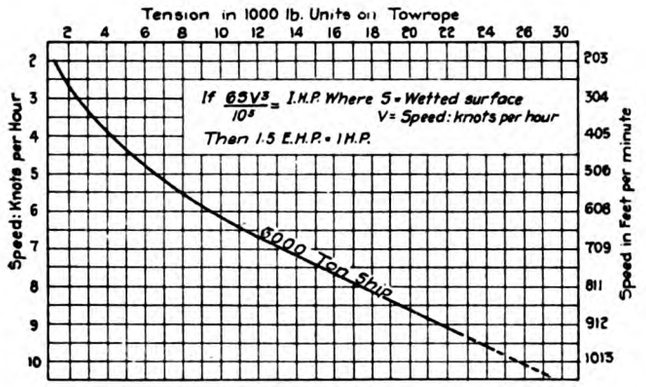
Let tons per inch immersion $= T = \frac{LB}{500} = \frac{100 \times 40}{500}$ $= 8$ tons.

Then to alter trim 1 in. $= \frac{31\ T}{B} = 6.1$ foot-tons transverse, and $\frac{94 \times 342}{172 \times 3} = 62$ foot-tons longitudinal.

The change of trim forward and aft will be in the ratio of 47 to 53.


Tension in 1000 lb. Units on Towrope
2 4 6 8 10 12 14 16 18 20 22 24 26 30
Speed: Knots per Hour
2 3 4 5 6 7 8 9 10
If $\frac{65V^3}{10^3}$ = I.H.P. Where S = Wetted surface
V = Speed: knots per hour
Then 1.5 E.H.P. = I.H.P.
6000 Ton Ship
203 304 405 506 608 709 811 912 1013
Speed in Feet per minute

RESISTANCE-WAVES

In computing frames assuming them as having free ends, then $M = \frac{wl^2}{15.5}$. With fixed ends $M = \frac{wl^2}{46.7}$ and $-M = \frac{wl^2}{20}$. With the bottom alone fixed, $M = \frac{wl^2}{33.6}$, $-M = \frac{wl^2}{15}$. For the upper end alone fixed, $M = \frac{wl^2}{23.6}$ and $-M = \frac{wl^2}{17.1}$. $w =$ maximum pressure near bottom $= \frac{y}{35}$.

The strength of ships may also be computed by considering either the bottom or the deck as a two-hinged arch.

Let $b =$ span of frame centre to centre of side-walls.
$h =$ height of frame.
$R = \frac{b}{h} =$ ratio of span to height.
$I_1 =$ moment of inertia of cross-section of top or bottom for one unit of length of hull.
$I_2 =$ moment of inertia of cross-section of either side for one unit of length.
$S =$ ratio of moment of inertia of top or bottom to that of either side.
$w =$ uniform load per unit of area on top or bottom.

Then, following the analysis for a two-hinged arch:

$$H = \frac{wb}{4} \frac{R^2}{2S + 3R}$$

$M_c = \frac{wb^2}{8} - Hh =$ moment at keel.

$M_a = -Hh =$ moment at bilge.

Assume $I_1 = 4$ and $I_2 = 1$

$w = 5 \times 0.25 = 1.25$ tons

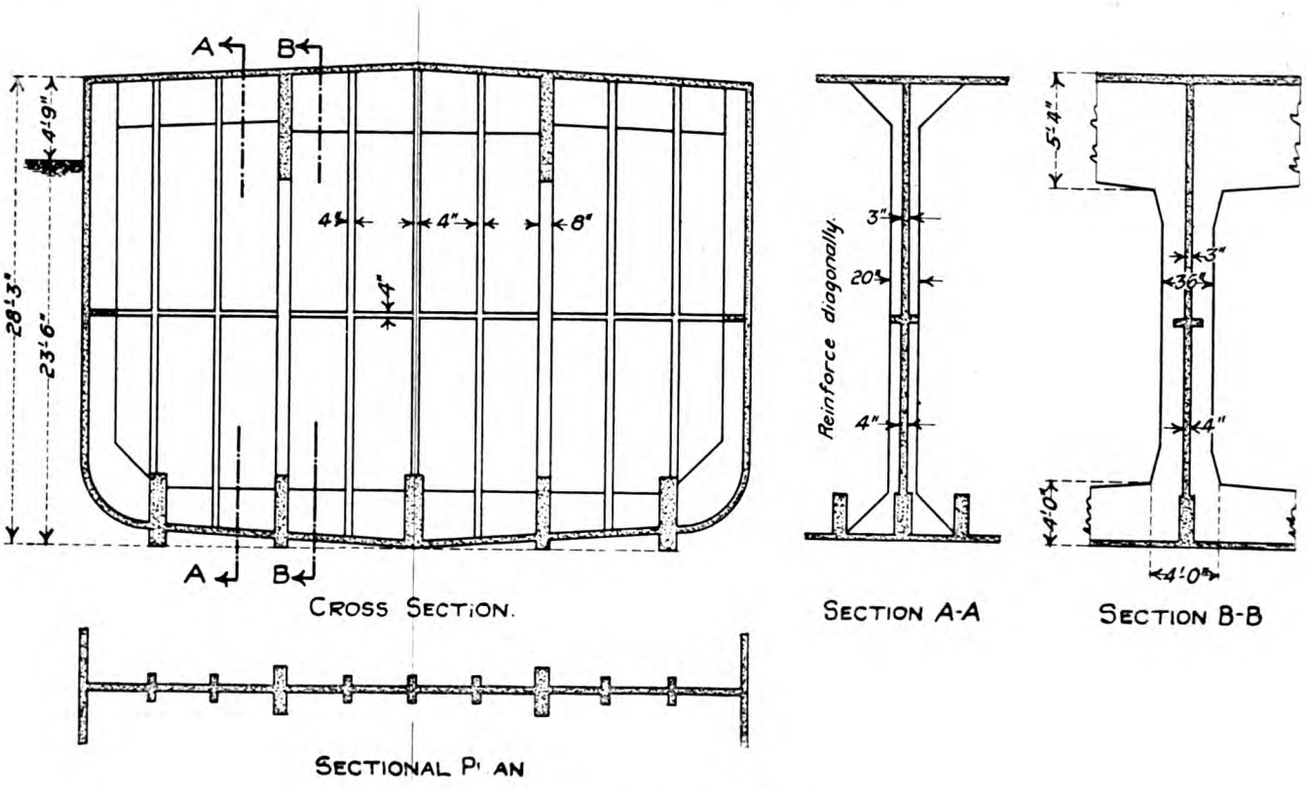
$b = 40$, $h = 28$, $R = 1.42$ $S = 4$

$$H = \frac{1.25 \times 40 \times 1.42 \times 1.42}{4(8 + 4.26)} = 2.04$$

$$M_c = \frac{1.25 \times 40 \times 40}{8} - 2.08 \times 28 = 193 \text{ ft. tons.}$$

$M_a\ 2.04 \times 28 = -57$ ft. tons.

In the analysis of stress in a tee-beam in the bottom of a ship, assume a beam with the tee 60 in. wide and 5 in. thick, the upright 31 in. from bottom of tee to reinforcement and the upright of the beam 7 in. thick. Use nine $1\frac{1}{8}$-in. bars for reinforcement. Then to find position




BULKHEAD PLAN AND SECTION

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of neutral axis, neglecting steel in slab and assuming $n = 10$, $(53 \times 5)(y - 2\frac{1}{2}) + 3.5y = (11.39 \times 10)(31 - y)$, and $y = 10$ in.

The moment of inertia about this axis is

$nI_s = 10 \times 11.39 \times 21 \times 21$

$I_c = (60 \times 10 \times 10 \times 10 \times 0.333) - (53 \times 5 \times 5 \times 5 \times 0.333)$

The resisting moment =

$$\frac{f_c I}{y} = M_c = \frac{1000 \times 67800}{10} = 6{,}780{,}000 \text{ in.-lb.}$$

$$\frac{f_s I}{n(d-y)} = M_s = \frac{16000 \times 67800}{10 \times 21} = 5{,}200{,}000 \text{ in.-lb.}$$

The stress = 193 ft.-tons = 5,200,000 lb. at centre.

Designing the frame according to the loading suggested by the Union of Danish Engineers, namely the ship completely loaded on one side of the keel and unloaded on the other but without using their formula, we have the following for an open frame:

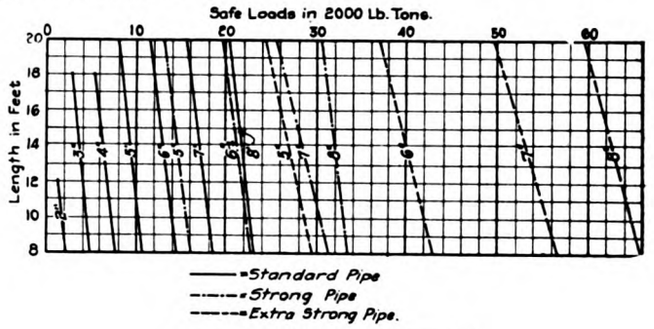
$h = 28.25$ ft., $h_o = 27.5$ ft., $h_1 = 0.75\ R$ and $S$ as above, then

$$H = \frac{wl^2}{64} \frac{R(3h_o + 5h}{h_o^2 S - R(3h_o h - h_1^2)}, \text{ from which } H = 3.4 \text{ tons.}$$

$$M_c = \frac{wl^2}{16} - Hh, \text{ from which } M_c = 294 \text{ foot-tons.}$$

Assume a tee-beam with the bar of the tee 60 in. wide and 5 in. thick with six $1\frac{1}{8}$-in. square bars at the centre, and the upright of the tee 31 in. high from the bottom of the bar, 7 in. thick, with twelve $1\frac{1}{8}$-in. square bars at the head. The transformed area of the compressive steel = $10 \times 25.1 = 251$ and the tensile steel = $10 \times 15.2 = 152$. Equating statical moments and solving, $y$ or the distance of the neutral axis above the bottom of the tee is 9.5 in., $f_c = 700$ lb. per sq. in., $f_s^1 = 5120$ lb. per sq. in., and $f_s = 15{,}800$ lb. per sq. in. Maximum shear at neutral axis = $\frac{3V}{2bd}$. The maximum positive shear at any point, $c$, $V_c = \frac{V_a}{l^2}(l - x)^2$.

At the centre, the shear would be 19.5 tons, requiring 163 sq. in. of concrete to bring the stress down to 400 lb. per square inch.




STRENGTH OF PIPE-COLUMNS

The moment for the deck fore and aft girders =

$$\frac{2.7 \times 50 \times 50}{24} = 282 \text{ foot-tons.}$$

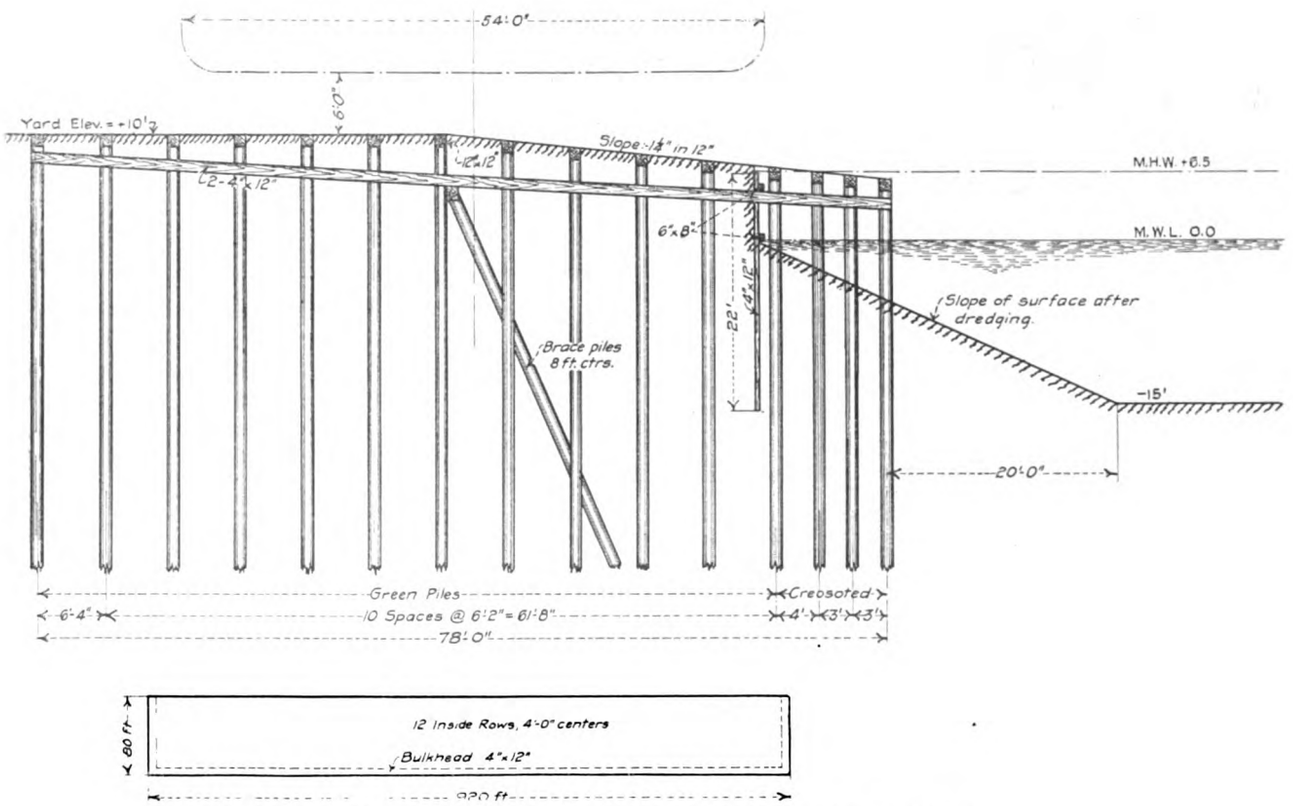
$$A_s = \frac{282 \times 12}{6.25 \times 47.5} = 11.4 \text{ sq. in.}$$

$$\frac{2.7 \times 45 \times 45}{24} = 225 \text{ foot-tons.}$$

$$A_s = \frac{225 \times 12}{6.25 \times 38} = 11.4 \text{ sq. in.}$$

$$\frac{2.7 \times 40 \times 40}{24} = 180 \text{ foot-tons.}$$

$$A_s = \frac{180 \times 12}{6.25 \times 30.5} = 11.4 \text{ sq. in.}$$




WAYS FOR BUILDING CONCRETE SHIPS AT OAKLAND ESTUARY

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The longitudinal girders in the bottom, besides transferring loads to the transverse floors are good for a moment equal to $\frac{1.75 \times 50 \times 50}{24} = 180$ tons and $A_s = \frac{180 \times 12}{6.25 \times 31} = 11.4$ sq. in., corresponding to a pressure of 0.25 ton per sq. in. on the bottom. This is perhaps the average stress.

While this article deals more with the design than with the actual construction of concrete ships, the following notes may be pertinent. Allow 3 bbl. of cement per cubic yard of concrete, say 0.5 bbl. per ton displacement. The hardest and densest mixture will be found to make the lightest ship. Searching for light aggregates for either the shell, beams, or bulkheads is fatuous. Unit-stresses for concrete of 1000 lb. per square inch in compression and 400 lb. in shear are now considered conservative, and some designs are being made on the basis of stresses 50% higher. If concrete with a comparative strength of 3500 to 4000 lb. per square inch can be produced, the covering over the steel can be made quite thin. Observation of the action of salt water on the concrete piers in San Francisco has indicated that a 0.5-in. covering is more durable than a 2-in. covering. As far as protecting the steel is concerned, only the part subject to rise and fall of the sea needs to be considered. This would limit the part needing protection to the outside steel between light and load water line. Galvanizing adds $40 per ton to the cost of the steel. Other proposed methods of protection are less expensive. Waterproofness of the concrete had better be sought in a dense mixture than in the addition of foreign material. The success of concrete ships depends largely upon the quality of the cement used. In pouring concrete it is possible that the greatest success will be attained with an enlarged and improved type of the present grouting machines. Such a machine should be operated at a pressure of at least 100 lb. per square inch. This will require very rigid forms. The amount of water should also be under control. About 5 or 6 gal. of water per sack of cement or 60 to 70 gal. per cubic yard of concrete is the proper amount for a 3000-lb. concrete. Less water should be used if a stronger concrete is desired. This amount of water will ensure the compacting of the concrete around the steel. The finished concrete should have the same appearance as concrete pipe that has been made under hydraulic pressure. The rock used should not exceed ½ in. diam. The cement-gun and the present air-machines have not been satisfactory.

Side-launching is the recognized method for concrete ships at the present time, semingly from a distrust of the ship itself, or else so that it may be launched more quickly than if allowed a longer time to set so as to take the added stresses before and after launching.

No stanchions are used in the design. If any are to be provided, preference should be given to wrought-iron pipe. Concrete columns are too heavy for economical use.

The weight of a concrete ship can readily be made as small as a wooden ship of the same carrying capacity, and it should be possible to design a concrete vessel almost as light as a steel ship. At the present prices of materials and labor, two concrete hulls can be constructed for the same cost as one steel ship of the same carrying capacity and five concrete hulls for the cost of four wooden hulls. Single-deck cargo-ships up to 6000 tons capacity and tank-steamers up to 10,000 tons will be the most popular types. Such ships should cost $50 per dead-weight ton for concrete, $20 for fittings, and $55 for engines. Concrete barges will become popular as soon as their merits are better known.

The ship described in this article is typical of the present construction ideas, which are based on the assumption of duplicating the arrangements of beams in a steel ship. This is not the best nor the lightest possible design, as will be shown in a later article. The design and construction of concrete ships will pass through the same stages as the design and construction of concrete buildings, but the evolution will be more rapid.

---

**Cost** of operating aeroplanes in the postal service between New York and Washington for the first month was $0.50 per mile on average. This includes overhead charges, interest on investment, salaries, and supplies, but apparently does not include depreciation. The total distance covered was 7234 miles and the average speed 65 miles per hour. The average mileage per gallon of gasoline was 5.2.

---

**Heat** lost in escaping flue-gases amounts to 0.24 B.t.u. per pound of gas per degree F. temperature of gas above temperature of steam in the boiler. This loss cannot be eliminated entirely. For plants operating on natural draft a temperature of about 500° F. is required in the stack to produce the necessary draft. An average temperature of 550° F. is good practice. With forced draft and four-pass boilers this temperature may be reduced somewhat.

---

**When threading** a polished brass tube of small diameter it is difficult to grip it tightly without marring the surface or crushing the tube. One method that has been applied effectively is this: Clamp the pipe-stock in a vise. Then in one end of the tube drive a 12-in. round or rat-tail file. Grip the square end of the file with a monkey wrench and turn the tube with it into the die. Thus the threading is effected without marring the cylinder.—L. G. Geary in 'National Engineer.'

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**Powdered coal** burns best with an air supply of 200 cu. ft. of air per pound. It can burn and burn clearly, with 160 cu. ft. or even less, but the excess pays. When the supply exceeds 200 cu. ft., the efficiency begins to fall. There is a noticeable loss even at 208 cu. ft. The eye cannot discriminate between a 200 and a 208 cu. ft. fire, but it can recognize a 220-cu. ft. blaze. There is a marked change in the appearance and unless a 'cutting fire' is desired there is no excuse for such bad mixtures. —C. F. Herington in 'National Engineer.'

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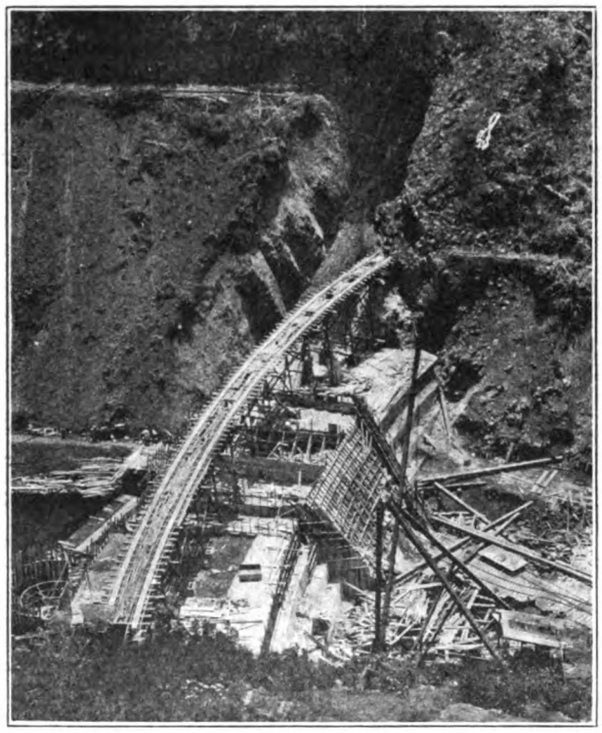
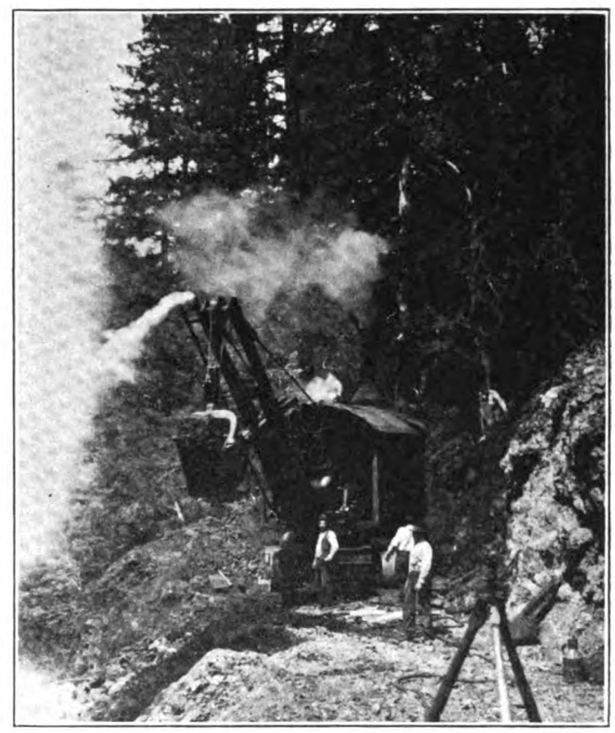
# Construction of Collection and Transmission System for Marin Municipal Water District

The Marin Municipal water district comprises, as shown on the accompanying map, the more thickly populated part of Marin county, including the city of San Rafael and the towns of Fairfax, San Anselmo, Ross, Kentfield, Sausalito, Belvedere, Mill Valley, and Corte Madera, together with the adjacent unincorporated territory. It was organized in 1912 under an Act of the legislature commonly known as the 'Water District Act,' providing for the combination of two or more municipalities, or of municipalities and unincorporated territory to acquire a water supply. Five directors were elected from the district at large, one director was appointed for each of the eight municipalities, and one director was appointed for the unincorporated territory.



ALPINE DAM, MAY 29, 1918



STEAM-SHOVEL AT WORK ON PIPE-LINE ROAD

Most of the residents of the district are 'commuters' in business in San Francisco. The total population of the district was about 21,000 in 1910, but is considerably greater at the present time, as will be seen from the fact that the district's water system supplies about 7000 services, not counting those parts of the district that are still being supplied from private sources. The summer population of the district is considerably larger than the winter population, both because many of the 'commuters' live in San Francisco during the winter and because there is also a considerable non-commuting transient population.

Before the organization of the district the residents were served by several private water companies. The principal one, the Marin Water & Power Co., was organized in the early 'seventies, and supplied the residents of San Rafael, Ross, Kentfield, San Anselmo, and Fairfax, together with some unincorporated territory, also selling water by wholesale to the town of Sausalito. The collecting system consisted mainly of two storage reservoirs, Lake Lagunitas and Phoenix lake with a total capacity of 380,000,000 gal. From Phoenix lake, water is pumped in a 12-in. main through Ross and San Anselmo to San Rafael. At San Rafael there are two small distributing reservoirs. Lake Lagunitas is at a sufficient elevation so that no pumping is required. From it an 18-in. main runs to Sausalito, reducing on the way to a 16-in. and then a 12-in. main. The catchment-area of the reservoirs is mountainous and covered in the main with considerable timber and brush. The growth of population rendered the Marin company's system inadequate and at the time the district was formed, plans had been completed and some preliminary work had been done on the so-called Bon Tempe or Tamalpais reservoir, which would have increased by about 3,000,000 gal. the daily safe draft on the company's system of rather less than 2,000,000 gallons.

The North Coast Water Co. supplied the town of Mill

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MAP OF MARIN MUNICIPAL WATER DISTRICT

Valley and the vicinity. Water was obtained from springs in the neighborhood and stored in four distributing reservoirs at various elevations. The systems of both the Marin Water & Power Co. and the North Coast Water Co. were acquired by the district under condemnation proceedings, the former for $1,200,150 and the latter for $289,200. There are several other small private companies supplying various small areas in the district, water being obtained from wells and springs. These smaller systems will ultimately be acquired by the district.

A bond issue for $3,000,000 was voted in August 1915. Although the constitutionality of the Act authorizing the formation of municipal water districts was sustained, the bonds of the district did not prove attractive to investors. They were finally sold at a price that yielded the district about $2,835,000, although these bonds have subsequently been sold at par. Of this amount, as will be seen above, over half was used for the purchase of the systems of the two water companies. An additional amount of $137,625.83 was paid to the Howard-Shafter estate for additional watershed lands, leaving

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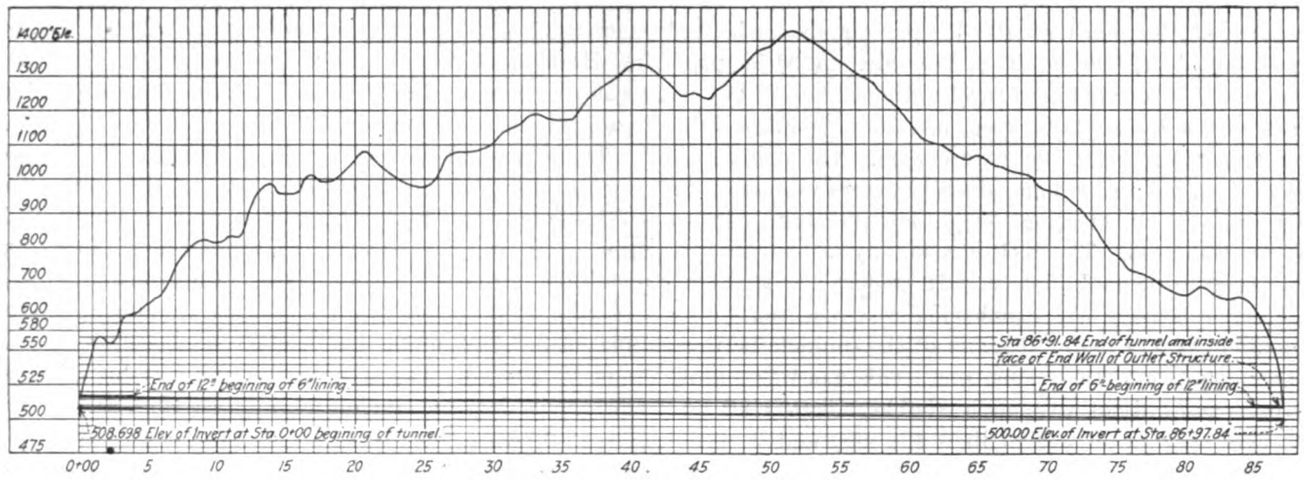
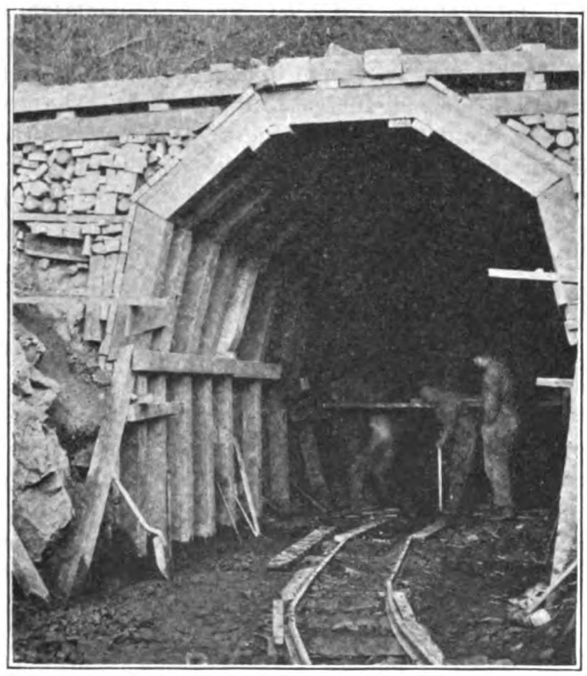



PROFILE OF PINE MOUNTAIN TUNNEL

about $1,200,000 for extension of the system and for all overhead and incidental expenses.

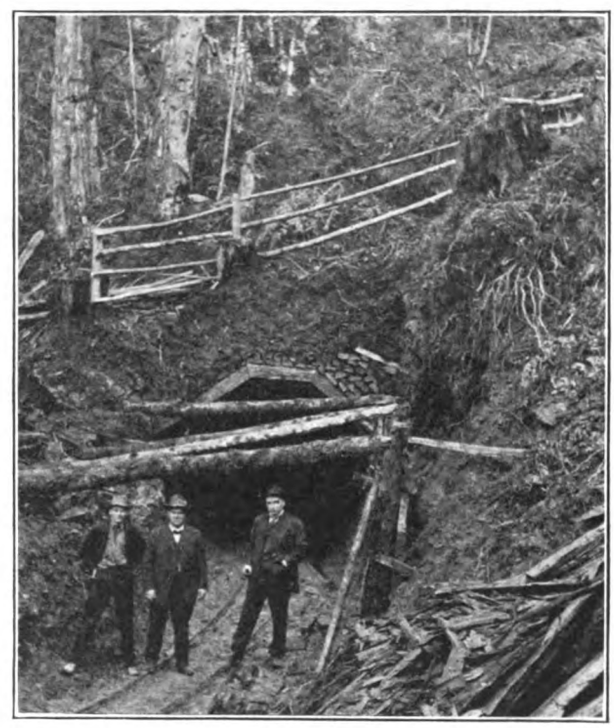
While some additions have been made to the distribution system, most of the work now under way is on the collection and transmission systems. This work is in three principal divisions, the Alpine dam, a concrete structure of gravity section on Lagunitas creek, the Pine Mountain tunnel, a concrete-lined tunnel 8700 ft. long,



EAST PORTAL OF TUNNEL

and a 24-in. concrete pipe-line 7 miles long, 3½ miles of which extends from the dam-site to the upper portal of the Pine Mountain tunnel and 3½ miles extends from the lower portal of the tunnel to the Phoenix Lake gate-house. For various reasons the Bon Tempe project was abandoned in favor of the dam on Lagunitas creek.

Contract for construction of the Pine Mountain tunnel was awarded in December 1916 to McLeran & Peterson, of San Francisco, for $29.70 per lin. ft. or $257,400 for the entire work. Methods of driving this tunnel were described in WESTERN ENGINEERING for July 1917. In brief, work was commenced early in December 1916, hand-drills being used until February, when the compressor-plant was completed and machine-drills were used from that time until the tunnel was 'holed through'



WEST PORTAL OF TUNNEL

in March 1918. The tunnel has a horseshoe-shaped section 8 ft. in the clear inside the concrete lining. The concrete lining is 6 in. thick for most of the tunnel and 12 in. thick in the soft ground at the two portals.

The power-plant was placed at a point on the Bolinas road about three miles west of Fairfax. The east portal was about 1000 ft. from the power-plant and the west portal about two miles. The plant consisted of three 25-hp. Fairbanks-Morse Y-type semi-diesel engines and

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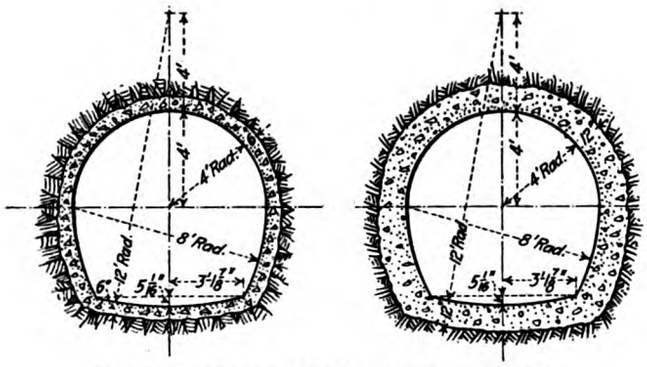
three 8 by 8-in. Sullivan compressors, maintaining a pressure at the plant of 100 lb. per square inch, and supplying about 300 cu. ft. of free air. A 3½-in. pipe-line conveyed the air to the two headings. No. 18 Leyner drills with a 1¼-in., 24-in. feed, and sets of hollow drill-steel from 24 to 96 in. long were used. The drills were mounted on horizontal bars. Jack-hammers were used for trimming. For blasting, 40% low-freezing gelatine powder was used. The rock was mainly sandstone with some serpentine and diabase. In general, it stood up well and relatively little timbering was required. Considerable gas was found at many of the contacts between the sandstone and the serpentine. This gas was mainly methane and did not give much trouble. Usually all that was necessary to do was to light the gas, and it would




TUNNEL SECTIONS IN HARD AND SOFT ROCK

burn out in a few hours. The products of combustion were removed by the regular ventilating system. No bad effect on the health of the workmen was observed. 'Pockets' of water were found at a number of points. A ditch was dug in the invert of the tunnel to drain the water away, which seldom took more than a few days for any one seam. At the west or upper end of the tunnel pumping was also required.

Placing the concrete-lining was sub-let to the Cahill-Vensano Co., of San Francisco. The mixer was placed at the east portal, which is the one nearest Fairfax, the principal railroad point for all the work. Rock for the concrete was obtained by opening a small quarry just above the mixer. The concrete was hauled in 1½-yd. cars on an industrial track. Animal power was used for hauling at first, and when the length of haul became considerable, small steam-tractors made from converted automobiles were substituted. The sides and top of the tunnel were lined first, the work following as close to the heading as was feasible. When the sides and top were finished the work of lining was started from a point near the west portal and carried back toward the mixer. On August 20 the lining was nearly completed. Until the tunnel was 'holed through' the progress of the work of lining was limited somewhat by the progress in driving. After the driving was completed three 8-hour shifts of about 20 men each were employed on the concrete lining.

The work of clearing the reservoir-site was done in the early part of 1917. This involved the removal of a large amount of heavy timber and brush. Contract for the construction of the Alpine dam was awarded to Leonard & Hansen, of San Francisco, in June 1917 and work was commenced shortly after that time. Work did not progress in a satisfactory manner and, on January 14, 1918, it was taken over by the district under arrangement with the bonding company for the contractors. The contractors' plant was soon found to be unsuitable and work was temporarily suspended until new plant could be purchased and installed. Work was resumed on April 6. Since that time the average amount of concrete placed per day in one 8-hour shift has been between 125 and 150 cu. yd. The actual operating cost for labor and materials, but not including interest and depreciation on equipment, has been about $7.50 per cubic yard. Common labor is paid 45c. and 50c. and concrete workers 50c. and 60c. per hour.

The dam is a concrete structure of gravity-section, arched slightly up-stream. It will be 100 ft. high and will contain 27,000 cu. yd. of concrete. The storage capacity of the reservoir will be 1,000,000,000 gal. and the safe draft is 5,000,000 gal. per day. When the population of the district has increased so as to require more water than this amount plus the 2,000,000 gal. per day obtained from the system formerly owned by the Marin Water & Power Co., it is proposed to increase the height of the dam to 170 ft., which will give a reservoir capacity of 6,390,000,000 gal. and a safe draft of 15,000,000 gal. per day. No preparation has been made in the present work for this increase except to demonstrate that the site will permit such an increase at any time. The cross-section of the dam through one of the siphon spillways is shown in Fig. 1. The character of the site is such that an ordinary spillway around the side of the dam was not feasible, so a siphon-spillway was chosen. Plans for the spillway were prepared by A. R. Baker and approved by G. F. Stickney, of Albany, New York, holder of the patent for this type of spillway. The outlet-tower is at the left of the dam looking up-stream and will contain 'staggered' openings at various elevations, permitting water to be drawn from any level of the reservoir. A 30-in. cast-iron outlet-pipe extends below the dam for a few hundred feet to a weir-house, from which point the concrete transmission-line starts. An inspection-gallery runs through the body of the dam, and is arranged so as to receive whatever seepage may occur. To facilitate this, square columns of concrete with a large amount of voids are constructed at intervals in the body of the dam and connecting with the inspection-gallery, with the idea that these will assist in carrying the seepage into the gallery. So great is the force of habit that it is hard to get the workmen to make these columns of sufficiently 'inferior' concrete. After stripping the site of the dam to bedrock, holes were drilled 25 ft. into the bedrock and cement grout will be forced through pipes, extending through the concrete into the inspection gallery, thus closing all the seams in the rock. Three vertical expansion-joints are placed in the body of the dam, the method of making these being illustrated in Fig. 3.

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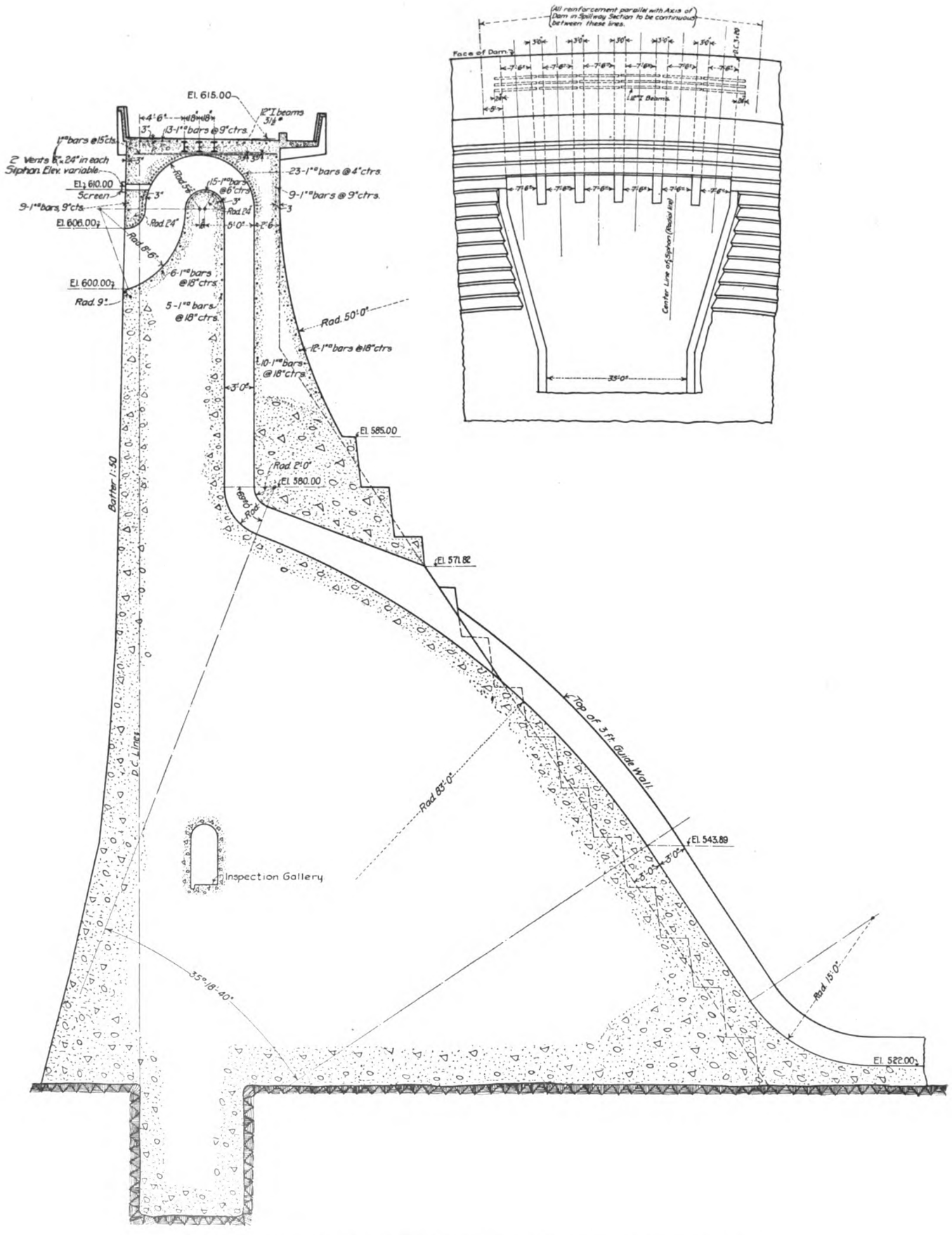


FIG. 1. SECTION OF DAM THROUGH SPILLWAY AND PLAN OF SPILLWAY

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Rock for concrete is obtained from a quarry above the dam and a sufficient distance down-stream so that rocks from blasting do not interfere with the work at the dam. The most economical method of quarrying is to run 'coyote-holes' so as to break a large amount of rock. After this has been done, the amount of blasting required is relatively small. The rock is seamy, but it is comparatively easy to select the harder rock for the concrete. The crushing and mixing plant has been arranged on the hillside so as to permit the maximum amount of work being done by gravity. The rock passes first through a No. 5 Austin crusher and is separated with an Austin screen, the 'sized' rock going into the rock-bin and the oversize being crushed in two No. 2 Austin crushers. These discharge on a set of Allis-Chalmers rolls, which in turn discharge into a sand-screen made by Muir & Symon. This sand-screen discharges into the sand-bin, the rejected material being run again through the rolls. To produce a mixture of maximum density, a limited amount of Antioch sand is added. This and the cement are hauled from Fairfax and stored just above the mixer. From the mixer the concrete is conveyed by a chute to a bunker placed just above the elevation of the crest of the completed dam. At the crest-elevation, a trestle has been constructed on a level grade carrying two industrial tracks. Koppel side-dumping cars of about 18 cu. ft. capacity carry the concrete from the bunker to a flexible hose above the point of deposition. One man can easily run a loaded car at a walking pace. The flexible iron hose is placed just above the work and can be moved to any desired point. Three men are needed at the lower end of the hose to control and spread the concrete. Concrete is constructed in 'dove-tailed' blocks, 5 ft. high and of sufficient size so that one block can be poured per day. Before commencing work on a block in the morning the laitance is removed and the entire surface roughened so as to produce a good bond. Some modification of the size and shape of the blocks is, of course, necessary in building the spillway-sections. A 1:3½:7 mixture is used except for the up-stream face, which is 1:2½:5 with 6% hydrated lime.

From the weir-house, a concrete pipe-line will extend down the canyon 3½ miles to the west portal of the Pine Mountain tunnel. This pipe has an inside diameter of 24 in. and a capacity of 5,000,000 gal. per day. To provide a bench for this pipe and also a means for hauling supplies, a road has been constructed on a grade of one foot in 1000, the same grade as the pipe-line. A trench will be cut in the road to receive the pipe and then back-filled. When the reservoir-capacity has been fully developed there will be three pipes of this size, with a total capacity of 15,000,000 gal. To provide a solid bed for the pipe, the road has been built almost entirely in cut. The maximum curvature allowed in the pipe is 75° and the road has been built in accordance with this requirement. These two requirements made necessary a considerable amount of heavy excavation and some thorough cuts. Where going around the head of a draw with the road made it necessary to exceed this curvature, a trestle was constructed for the pipe-line. These trestles are built of concrete on account of the fire risk, and the pipe rests on concrete cradles. Although the construction of the road required a large amount of excavation the fact that practically all the material could be wasted over the side made it possible for the contractor to do the work with a steam-shovel at a comparatively low unit price.

Below the Pine Mountain tunnel, a concrete pipe-line of the same size and 3½ miles long will carry the water to a connection with the present system at the Phoenix Lake gate-house. A road for hauling and for a pipe-bench was constructed in much the same way as the one above the tunnel. From the tunnel to the Fairfax-Bolinas county road provision is made for three pipes on the trestles, although, as is the case above the tunnel, only one will be constructed at the present time. Since a large part of the district will receive water from points above this county road, provision for only two pipe-lines is made below this point. Ultimately a 24-in. concrete pipe-line will be constructed from the Phoenix gate-house to Mill Valley, but no work on this part of the system will be done at the present time.

The construction of the road along the pipe-line was done by contract. Digging and back-filling the pipe-trench is being done by the district. Making and laying the pipe is being done by Bent Bros., of Los Angeles, under a 'cost-plus' contract. The pipe is cast at Fairfax. The thickness is 3 in., making the outside diameter 30 in. The sections are 36 in. long and weigh 750 lb. Twelve of them can be hauled on a 5-ton motor truck. The reinforcement is made of ¼-in. wire, there being four upright wires and several spiral hoops. The pipe enters the Pine Mountain tunnel at the top, so that above the tunnel it is under practically no pressure. The pipe leaves the tunnel at the bottom so that below the tunnel it is under slight pressure. The reinforcing hoops are therefore spaced 4.71 in. centre to centre for the pipe above the tunnel and 3.33 in. for the pipe below the tunnel.

For the curves, special pipe-sections are cast which are 36 in. long on the outside of the curve and 34⅝ in. long on the inside. This pipe is used for the 75° curves, the sharpest that are used. The alignment of the road and pipe-trench is arranged so that the only curves used are those that can be made by simple combinations of straight and special pipe.

A 1:2:4 mixture is used for the pipe. Santa Cruz cement and Russian River sand and gravel are used, with the addition of sufficient Rio Vista sand to give a mixture of maximum density. Steel inside and outside forms are used. The length of time the forms are left on the pipe depends somewhat on the weather and the time of day that the particular pipe was cast. In warm weather the forms can frequently be removed in the afternoon from pipe cast in the morning. Usually, however, the forms are left on the pipe over night. After the forms are removed the pipe is kept wet for seven days. From 150 to 200 ft. of pipe is cast in one day and

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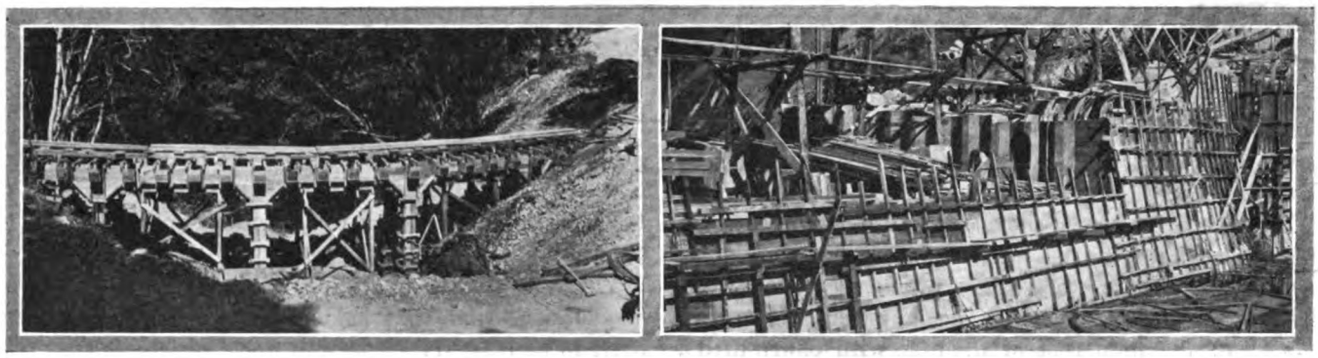
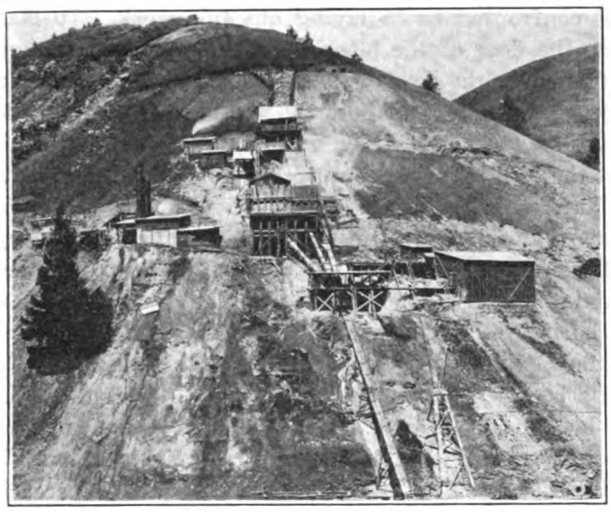


FIG. 2 AND 3. FORMS FOR CONCRETE TRESTLE AND PART OF DAM, SHOWING EXPANSION JOINTS

from 6000 to 8000 gal. of water is used for mixing concrete and for spraying the pipe. The ends of the pipe are arranged so that when they are fitted together there is a small recess at the joint extending all around the pipe. In making the joint, a strip of waterproof cloth is first placed around the pipe. Grout is then poured into the joint at one side until it rises on the other side of the pipe. This is determined by sticking a wire into the recess on the other side. If the grout does not rise,



QUARRY AND CRUSHING AND MIXING PLANTS AT ALPINE DAM

the workmen investigate the cause, whether the recess has been choked by dirt or whether the grout is leaking away. If everything is satisfactory the grout is then poured in at the top until the joint is filled, when the waterproof cloth is brought around the joint. This confines the moisture and a tight joint is obtained. In the trench the pipe is backfilled soon after the joint is made. On the trestles evaporation is retarded by placing wet sacks over the joint.

Besides the work described above, several miles of new county road was graded in place of the part of the present Fairfax-Bolinas road that will be flooded by the Alpine reservoir. The new road will cross the canyon on top of the dam. Several short cast-iron pipe-lines have been constructed at various points to supplement the present distribution system, but the amount of this work has been limited by the funds available. This quantity has been smaller than was originally expected, partly because of increased costs of some of the work on account of the War, but mainly because of the necessity of selling the bonds of the district for less than par. However, in spite of limited funds, the policy of the district has been to build permanent structures, and to build them in such a way that increased capacity could be obtained when needed without abandoning any of the existing construction. Thus the Alpine reservoir, while constructed for a draft of 5,000,000 gal. per day, can be increased to 15,000,000 gal. per day by raising the dam. The capacity of the concrete pipe-lines can be increased to this figure by the simple process of building additional pipe-lines, for which the trestles and pipe-grade are already preared. The Pine Mountain tunnel was the only part of the system constructed for the ultimate capacity of 15,000,000 gal. per day, but enlargement of the tunnel would have been difficult while in service, and a tunnel of the size constructed costs but little more than a smaller tunnel.

The design and construction of the entire project from the time of the first surveys has been in charge of A. R. Baker, engineer for the district, with M. M. O'Shaughnessy as consulting engineer.

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**Electric stimulation** of crops was tried on small plots near Liverpool during the season of 1917. Fine wires were suspended from poles on either side of the electrified area. Much care was given to the insulation, which was triple, consisting for the principal insulators of long glass rods to the ends of which the live wires were attached. A high-tension current was discharged through the air to the plants and thence to the soil below. The crops from the 'electrified' ground was compared with the crops from similar ground cultivated in ordinary ways. While some crops showed little or no increase as a result of electric stimulation, the production of onions increased 633% and of sugar beets 390%.

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**Concrete** is being used for lining the main shaft of the Chief Consolidated Mining Co. at Eureka, Utah. This is the first mine-shaft in Utah to be lined with concrete. The work is being done by Villadsen Bros., of Salt Lake City.

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# Tunnel-Blasting at Chuquicamata

By E. E. BARKER

In blasting for steam-shovel work at Chuquicamata, where the height of the bench now being operated is about 180 ft., there were many problems to be solved before satisfactory work was accomplished. In consequence of the high cost of drilling with churn-drills, namely, $3.60 per foot, some other means of blasting had to be found. The excessive cost was due to the hardness of the rock, and to the many seams and fractures throughout the deposit, causing excessive breakage of tools. Also the high cost of coal ($23 per ton) was an important consideration. The comparison of drilling records on this material with those from drilling in such porphyries as the Nevada Consolidated orebody shows an average footage per 9-hr. shift at Chuquicamata of eight to twelve feet as against an average in Nevada of 60 ft. This large difference, together with the increased cost of supplies in South America, readily shows that churn-drill costs in the soft-porphyry mines cannot be equalled in the harder granite at Chuquicamata. This work at the Nevada Consolidated in normal times cost a maximum of 50c. per foot.

The higher the banks became, starting from the contour and finally reaching 180 ft., the more footage was necessary, so that, say in a 150-ft. bank, one had to balance a drill-hole of 150 ft., together with the expense of springing a pocket for the blasting charge, against the cost of running a mine-drift 25 ft., which was the spacing between the drill-holes. Blasting by churn-drills, even to a height of 60 ft., in this material, cost as high as 25c. per ton, so that it became evident early in the blasting operations that some other method must be devised. The result was that the blasting methods were changed from churn-drill holes to underground tunnels. It is surprising to find how little is written on the subject; accordingly the work in blasting by tunnels was experimental from the start.

Questions such as the following had to be solved:

1. How deep below the steam-shovel grade should blasting drifts be driven?

2. How deep into the bank, or at what horizontal distance, should the blasting-drifts be spaced?

3. Would it be possible to blast with the black powder in the containers piled as it were in a magazine, or would it be necessary to open the containers and deposit the powder loose in the blasting-chamber?

4. Would the danger of the operation of loading exclude the use of the method, and what plans for safety might be necessary to diminish this danger?

5. In blasting by electric current, what system of wiring should be used, whether series, multiple-arc, multiple-series, or series-multiple, and what voltage of current should be used?

6. Would it be necessary to concrete the cross-cut between blasting-drifts, or would run-of-mine tamping be sufficient?

7. Could mining operations (driving) be carried on at the same time that loading was in operation in the drift to be blasted?

8. What saving in cost could be effected by the tunnel-method of blasting over that of the churn-drill?

9. What kind of explosive should be used as a detonator, and what ratio should the detonation-charge bear to the blasting-charge, and how should it be placed?

10. In calculating the powder requirements for a given tonnage, should the powder charges be calculated on the cubic metres to be broken, or in direct proportion to the line of shear (least resistance)?

11. At what intervals should the blasting-charges be spaced along the drift to be loaded?

The above questions give an idea of the many problems that confronted us in laying out this work. To start with, the floor of the blasting-tunnels was placed three metres below the floor of the steam-shovel grade, and the horizontal depth into the bank was made 15 m. In deciding on the depth below grade, one had to be certain that the blasting-charges were low enough so as to leave no hard bottom for the steam-shovels. In the many blasts that followed, 3 m. was found to be satisfactory, and where the height of the bank was 45 m., the horizontal distance was increased to 30 m. It was found that the horizontal distance could be two-thirds of the height of the bank to be blasted, so that the spacing of the drifts became 15 m., 22½ m., or 30 m., depending upon the height of the bank. By exhaustive experiments it was ascertained that the best form of wiring was in multiple-series, that is to say, five strings of caps each, and these connected in multiple to the main blasting leads. In each case all charges were double-primed, each cap of the blasting-charge being connected to an independent series of wiring back to an independent transformer, both controlled by the one switch on the higher voltage-line, which in this case carried a current of 500 volts, so that in case of failure of any part of one series of connections, the blaster was protected by having the second series to depend upon. From the figures that follow, when it is realized that a blast of this kind may cost upward of $50,000 for its preparation before the blasting-switch is thrown, it is seen that great care must be exercised to insure success.

The detonation of these charges, the best spacing of which was found to be 10 m. centre to centre, was accomplished by the use of 60% nitro-glycerine dynamite; the proportions of dynamite used being 2% of the weight of the blasting-charge. The detonators consisted of two or three boxes of dynamite per charge, the top of one of which had been previously removed, a hole bored in each

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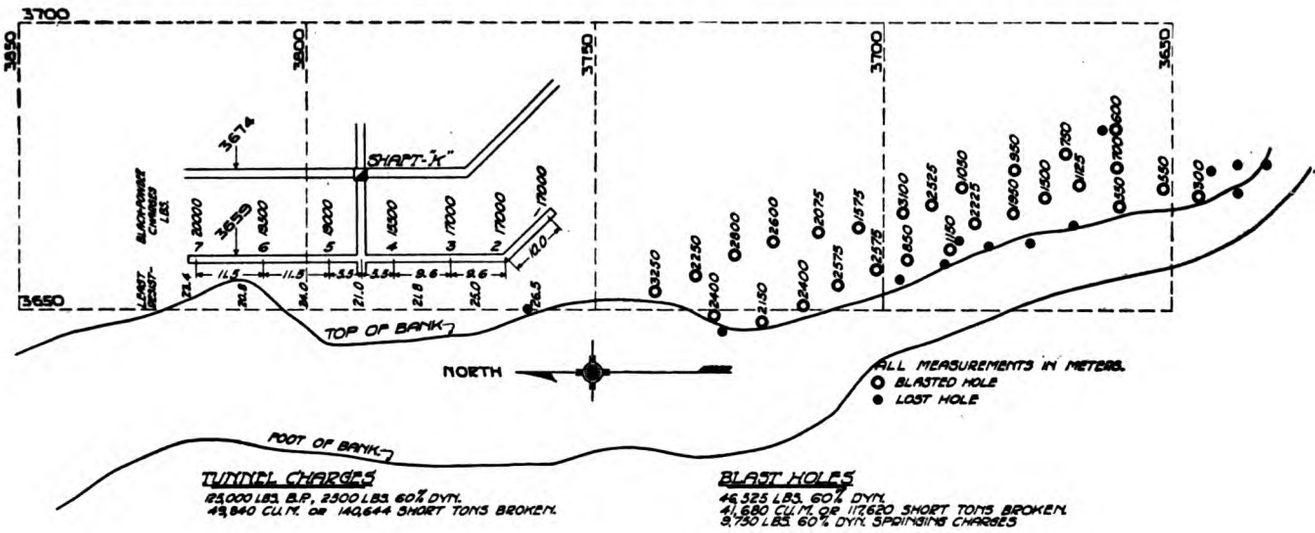
side of the case, and two sticks primed with a No. 6 electric exploder. The fuse-wires were placed through the hole of the box on each side, each cap being connected to its separate system of wiring. This case of dynamite, with others alongside, if necessary, was placed in the heart of the black-powder charge, which was loaded in the containers, cans, or sacks, as the case might be, without any attempt being made to open them. Each set of leading-wires was placed in grooved 2 by 3-in. lumber, and battened down with half-inch battens over the top of the groove. These conduits were placed one on either side at the bottom of the drift, the fuse-wires of each detonator being connected in series to its system of wiring.

The first blast fired was bulk-headed in the connecting cross-cut to the next in the rear by a 10-ft. block of concrete. After the shot, the concrete was so undisturbed that this procedure was found unnecessary, and the cross-cuts were subsequently filled with run-of-mine rock only. Since the gases formed by an explosion of black powder are said to be about 300 times the original volume at 60°F., and since the increase in volume for each 5° rise in temperature is 1%, it is estimated, from the fact that fused feldspars were found in the vicinity of the blast, that the temperature of the explosion is at least close to 2000°F. This would give a volume of gas 1164 times the volume occupied by the original charge, so that the refinements in loading with a charge of this size, in taking pains to fill all interstices and voids, is altogether unnecessary. The loss in explosive force would be at the most but a small fraction of one per cent. Since the gas is formed almost instantly, there is no time for this volume to get through the cross-cut tamped with mine-rock, and the breaking of the bank follows.

Although there is danger attached to all forms of blasting, when powder is handled without opening the containers, when electric safety-lamps are used, and strict regulations are enforced as to smoking and carrying matches, the danger of the operation is greatly minimized. Doors were placed in the cross-cuts at the entrance to the drifts to be loaded, with only the blaster and his crews having access to this compartment. The loading of the drifts was done at night, as there were fewer men on that shift working in the mine, and also fewer on the steam-shovel bench. As far as possible, it was aimed not to have steam-shovels working in front of the sections which were being loaded. It was found that mining operations could be carried on in the drifts next to those being loaded, so that this work need not be retarded during the time of loading. Blasting by tunnels is, of course, not new, but the usual way was by an adit with drifts. This was impracticable with steam-shovel work, because each time a shovel would pass the entrance to the tunnels would be lost, so that it became necessary to sink shafts some distance back from the working-face, and to drive the blasting-drifts from a cross-cut extended from the bottom of these shafts.




SECTION 1, NO. 10 SHOT FIRED NOVEMBER 19, 1916; ORE BROKEN 258,264 TONS

The largest blast at Chuquicamata was fired in three sections, the plans of which are given in Fig. 1, 2, and 3 respectively. That shown in Fig. 1, representing section 1, was blasted November 19, 1916; section 2, Fig. 2, November 21; section 3, Fig. 3, on November 26, 1916. These sections could have been fired simultaneously, except for the steam-shovel equipment, which had to be changed from one section to the other, so that ore-loading operations could be carried on without interruption, as the firing of the three sections would have tied up the greater part of the face. Section No. 1 consisted of 29 drill-holes in shallow ground, and 267.3 ft. of drift, as seen in the illustrations. Section No. 2 consisted of 29 churn-drill holes and 724 ft. of drift; in this case two parallel drifts being fired simultaneously. Section No. 3 consisted of 1318.6 ft. of drifts, showing a section in which 30 m. in horizontal distance was blasted for the first time. Details of the quantities used appear on each plan, but the grand total of explosives consisted of 813,000 lb. of black powder, and 85,850 lb. of dynamite, or 450 tons, which broke 1,229,716 tons of ore at a cost of

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10.59c. per ton. The cost of the blast by sections follows:

**Section I—Tunnels and Blast-Holes Separated**

Tunnel 'K', 3659—Blasted 11/19/16—7 charges

Ground broken, 49,840 m. = 65,188 cu. yd. = 140,644 short tons.

| | |
|---|---|
| Drifts and cross-cuts, 81.5 m. = 267.3 ft. at $13 | $3,474.90 |
| Filling, 50.9 m. at ₱13 Chilean pesos = ₱661.70 at $4.50 | 147.00 |
| Explosives: | |
| Black powder, 125,000 lb. at $0.0608 | 7,600.00 |
| 60% dynamite, 2500 lb. at $0.302 | 7.55 |
| Lead-wire, 1100 ft. at $4.25 per 500 ft | 9.35 |
| Exploders, 14 at $4.54 per 100 | 0.64 |
| Casing for wiring 600 linear ft., 500 board ft. at $72 and labor, etc. | 40.00 |
| Transportation (burros), 8 days at $10.53 | 84.24 |
| Labor: | |
| Loading gang, 5 days at ₱104 Chilean pesos = ₱520, at $4.50 | 115.50 |
| Hoist-man gang, 2 days at ₱9 Chilean pesos = ₱18, at $4.50 | 4.00 |
| | $12,230.63 |

8.7c. per ton.

**Churn-Drill Holes, South End—11/19/ 16**

Ground broken, 41,680 m. = 54,514 cu. yd. = 117,620 short tons.

Holes shot, 29.....1,944 ft.
Holes lost, 11..... 735 ft.

| | |
|---|---|
| 2,679 ft. at $3.60 | $9,644.40 |
| Springing (4 springs): | |
| 60% dynamite, 9750 lb. at $0.302 | 2,944.50 |
| Spool conducting-wire, 21,500 ft. at $0.0021 | 45.15 |
| Exploders, 160 at $4.54 per 100 | 7.26 |
| Labor (1st and 2nd springs, 20 in ½ day, 3rd and 4th springs, 20 in 1 day), 6 days at ₱104 Chilean pesos | 139.00 |
| Blasting charges: | |
| 60% dynamite, 46,975 lb. at $0.302 | 14,186.45 |
| Leading-wire, No. 14, 7800 ft. at $4.25 per 500 ft | 66.30 |
| Exploders, 58 at $4.54 per 100 | 2.63 |
| Labor, 5 holes per day, 6 days, at ₱104 Chilean pesos | 139.00 |
| Transportation (burros), 4 days, at $10.53 | 42.12 |
| | $27,216.81 |

23.1c. per short ton.

**Section II—Tunnels and Blast-Holes Separated**

Tunnels A 3569-3584—Blasted 11/21/16—21 charges

Ground broken, 72,190 m. = 94,420 cu. yd. = 203,714 short tons.

| | |
|---|---|
| Drifts and cross-cuts, 220.7 m. = 724 ft. at $13 | $9,412.00 |
| Filling, 178.2 m., at ₱13 Chilean pesos = ₱2316.60, at $4.50 | 515.00 |
| Explosives: | |
| Black powder, 165,900 lb. at $0.0608 | 10,086.70 |
| 60% dynamite, 3200 lb. at $0.302 | 966.40 |
| Leading-wire, 3000 ft. at $4.25 per 500 ft | 25.50 |
| Exploders, 42 at $4.54 per 100 | 1.91 |
| Casing for wiring, 1460 linear ft., 1220 bd. ft. at $72 and labor, etc. | 90.00 |
| Transportation, 10 days at $10.53 | 105.30 |
| Labor: | |
| Loading gang, 15 days at ₱104 Chilean pesos = ₱1560 at $4.50 | 347.00 |
| Hoist-man, 3 days at ₱9 Chilean pesos = ₱27 at $4.50 | 6.00 |
| | $21,555.81 |

10.6c. per ton.

**Churn-Drill Holes, North End—11/21/16**

Ground broken, 26,900 m. = 35,184 cu. yd. = 75,912 short tons.

Holes shot, 29.....1,263 ft.
Holes lost, 7..... 363 ft.

| | |
|---|---|
| 1,626 ft. at $3.60 | $5,853.60 |
| Springing (4 springs): | |
| 60% dynamite, 4240 lb. at $0.302 | 1,280.48 |
| Spool conducting-wire, 13,000 ft. at $0.0021 | 27.30 |
| Exploders, 144 at $4.54 per 100 | 6.54 |
| Labor (1st and 2nd, 20 springs in ½ day, 3rd and 4th, 20 springs in 1 day), 6 days at ₱104 Chilean pesos | 139.00 |
| Blasting charges: | |
| 60% dynamite, 23,375 lb. at $0.302 | 7,059.25 |
| Leading-wire, 5100 ft., at $4.25 per 500 ft | 43.35 |
| Exploders, 58 at $4.54 per 100 | 2.63 |
| Labor, 5 holes per day, 6 days at ₱104 Chilean pesos | 139.00 |
| Transportation, 3 days at $10.53 | 31.59 |
| | $14,582.74 |

19.2c. per short ton.

**Section III—Tunnels Only**

Tunnels, B 3629 T–T 3644 E—Blasted 11/26/16—36 charges

Ground broken, 320,655 cu. yd. = 691,826 short tons.

| | |
|---|---|
| Drifts and cross-cuts, 402 m. = 1318.6 ft. at $13 | $17,141.80 |
| Tamping, 9427 ft., 287.4 m. at ₱13 Chilean pesos | 830.26 |
| Explosives: | |
| Black powder, 522,100 lb. at $0.0608 | 31,743.68 |
| Dynamite, 60%, 7000 lb. at $0.302 | 2,114.00 |
| Dynamite, 62%, 2600 lb. at $0.6007 | 1,561.82 |
| Dynamite, 75%, 200 lb. at $0.30 | 60.00 |
| Leading-wire, 5500 ft. at $4.25 per 500 ft | 46.75 |
| Exploders, 72 at $4.54 per 100 | 3.77 |
| Casing for wiring, 2 lines, 2210 bd. ft., plus labor | 163.92 |
| Transportation, 30 days at $10.53 | 315.90 |
| Labor (loading-gang), 25 days at ₱105 Chilean pesos; hoist-man, 18 days at ₱9 Chilean pesos | 613.78 |
| | $54,595.68 |

7.9c. per short ton.

**Resume of All Three Sections**

| Tunnels blasted November 1916 | Short tons broken | Total cost | Cost per short ton, cents |
|---|---|---|---|
| K 3659 | 140,644 | $12,230.63 | 8.7 |
| B 3622 T–T 3644 E | 691,826 | 54,595.68 | 7.9 |
| A 3569–A 3584 | 203,714 | 21,555.81 | 10.6 |
| Total | 1,036,184 | $88,382.12 | 8.53 |
| Churn-drill holes November 1916 | | | |
| At south end of bench | 117,620 | $27,216.81 | 23.1 |
| At north end of bench | 75,912 | 14,582.74 | 19.2 |
| Total | 193,532 | $41,799.55 | 21.6 |
| Tunnels and blast-holes | | | |
| Tunnels | 1,036,184 | $88,382.12 | 8.53 |
| Blast-holes | 193,532 | 41,799.55 | 21.6 |
| Total | 1,229,716 | $130,181.67 | 10.59 |

**Unit Costs**

| Costs | Chilean pesos | U. S. currency |
|---|---|---|
| Driving, per ft | | $13.00 |
| Tamping, per metre | ₱13 | |
| Black powder, per lb | | 0.0608 |
| Dynamite, 60%, per lb | | 0.302 |
| Dynamite, 62%, per lb. (purchased locally) | | 0.6007 |
| Dynamite, 75%, per lb | | 0.30 |
| Leading-wire, per 500 ft | | 4.25 |
| Conducting-wire, 450 ft., 2-lb. spool | | 0.946 |
| Exploders, per 100 | | 4.54 |
| Casing for wiring, per 1000 bd. ft | | 72.00 |
| Labor: | | |
| Loading-gang (9 men), per day | 104 | |
| Hoist-man, per day | 9 | |
| Transportation: | | |
| 10 cargo burros, per day | | 4.00 |
| 3 burros for men, per day | | 1.20 |
| 1 capataz | 10 | |
| 2 burreros | 14 | |
| 9 trips of 2000 lb. per day. | | |
| Total for transportation, per day | | 10.53 |
| Blast-hole drilling, per ft | | 3.60 |

Casing for wiring, 2 lines for total length of drifts and cross-cuts.
Leading-wire, 4 lines for total length of drifts and cross-cuts.
Exploders, 2 for each tunnel-charge.
Exploders, 2 for each blast-hole.
Springing (4 times)—1st and 2nd, 20 springs in ½ day; 3rd and 4th, 20 springs in 1 day.
Loading blast-holes, 5 holes per day with dynamite.

The marked difference in the cost by tunnels, 8.53c., and the cost by churn-drill holes, 21.6c., was forcibly shown by the results of these blasts and proved conclusively that the tunnel-method was doing the work for less than half the cost of the same work by drill-holes. The above costs do not include the expense of block-holing the boulders, following the large blasts; this is taken up later. Neither is allowance made for the proportion of overhead expense.

Much controversy has arisen over the so-called method of high banks versus the method of low banks as applied to the work at Chuquicamata, the arguments being that the smaller the height of the bank, the smaller will the rock be broken, the safer the operation, and the more efficient the shovel-performance. On the other hand, with drill-holes, one is apt to have trouble with pockets, leaving hard rock in the bottom for the shovel to handle; missed holes are more likely to occur; and any delay to the churn-drill operation, resulting from lost holes, broken tools, and so on, would mean stoppage in steam-shovel loading, all of which would be reflected in the costs

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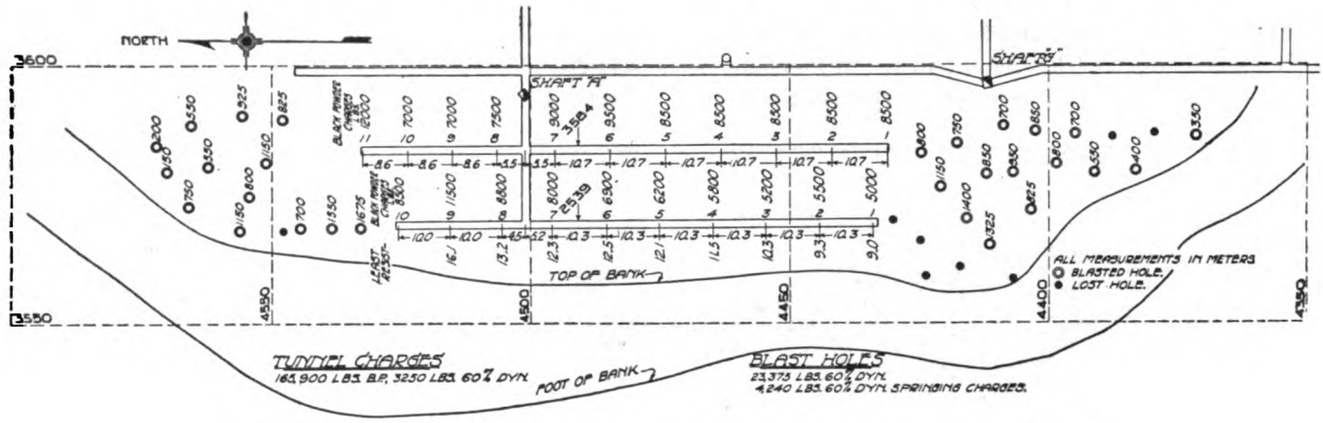
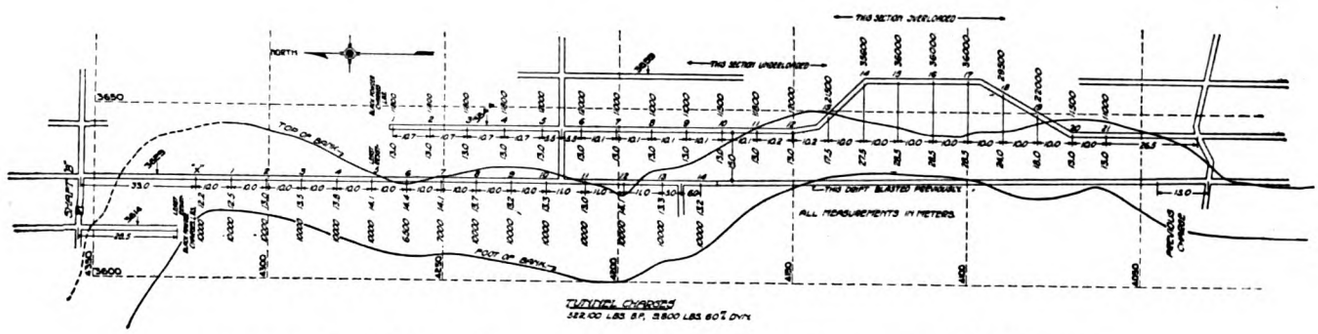
against the low-bank method. The question resolves itself into that of the cost per ton placed in the bins, and I do not believe that any increase in shovel-efficiency in the low banks, owing to a lower amount of large rock, will offset the large difference in cost by breaking the ground by the tunnel-method over that of the blast-hole method.

Churn-drills were used exclusively at Chuquicamata until the heights of the banks reached about 60 ft., and no greater than in any other form of blasting on a large scale. During the three years of blasting in this way at Chuquicamata, there never has been a miss-fire, although in the churn-drill blasting there have been several. Missed holes from churn-drill practice are largely accountable to the tamping scouring the leading or connecting wires, so that short circuits develop and the cap in one hole does not explode, while all the rest are detonated successfully. In blasting a string of holes one




SECTION 2, NO. 11 SHOT FIRED NOVEMBER 21, 1916; ORE BROKEN 279,626 TONS

coarse rock was produced continuously, which, together with the resulting hard bottoms, missed holes, and excessively high cost, resulted in this method being superceded by tunnel-blasting, the difference in cost being demonstrated above. In the case of the blast-holes fired in section 1, should there have been no lost holes, and should the net footage, namely, 1944 ft., have cost but $1 per foot instead of $3.60, we would have substituted $1944 for the $9644, and the total cost of the drill-hole missed hole is usually hard to locate, and it is not until the shovel is digging in this section that the unexploded charge is found, and in nine cases out of ten, the teeth of the dipper will be into the charge before the powder is discovered, so that the chance for accidents from this source is great. In blasting by the tunnel-method, the blaster's wiring connections, caps, and the like, are all within his reach, and can be inspected carefully, whereas in the drill-hole no one knows what has taken place; it




SECTION 3, NO. 12 SHOT FIRED NOVEMBER 26, 1916; ORE BROKEN 691,826 TONS

factor in this shot would be $19,516.81, or 16.6c. per ton, so that even with the high cost of drilling eliminated, the cost per ton broken would still be approximately twice that for breaking the ground in the same vicinity by tunnels.

A premature explosion, where the tunnel-method of blasting was used, might, of course, cause great loss of property and life, depending on the time when the accident occurred, but on summing up the premature explosions from drill-holes, or from other causes in any large blasting operation, the danger would appear to be must be taken for granted that the connections in the bottom of the hole are all right. A galvanometer test will show the hole to be safe, when really the wires are perhaps 'shorted' across the cap.

With regard to the large rock found in blasting hard-rock sections, the experience at Chuquicamata was that no matter how these hard sections were shot, the big rock could not be broken in the blasting. Tunnels have been overloaded as much as 100%, and underloaded so as merely to shake the bank, and the results, so far as big rock were concerned, were practically the same. This is

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true also in the good blasting ground, as the steam-shovel operator understands it, that is, ground that will break fine with low banks in churn-drill blasting also will break fine on a 150-ft. bank with tunnel-blasting. The illustration, Fig. 1, shows how fine the ore was broken in blasting a bank 160 ft. high. In the same photograph, it will be noticed that the blasted ground occupies about one-half the height of the original rock in place, and with the broken bank as shown, there is obtained the most ideal loading conditions as regards fineness of material and height above the loading-track, namely, between 40 and 50 ft. This height in no way endangers either the machine or the crew, and it ensures the greatest number of cars for each move forward consistent with good loading. In the last shovel-cut, where the machine is close to the bank, care must be used to have rocks endangering the machine barred down. For this reason it was decided not to clean up the blasts entirely, which meant the re-shooting of a small amount of ground already blasted. In the end this was more desirable than to clean up the face, thereby endangering the operating equipment.

There were times when hard blocky sections were undershot. This is a costly mistake, as a hard section of bank, which is only shaken, has to be fought with block-holing and jack-hammer work; this is tedious and costly. For that reason it invariably pays to be sure that enough powder is used to break the ground, and, for a safety factor, to overload from 20 to 30% in addition. On the other hand, too much of an overload scatters the bank, so that track shifting becomes excessive, and the resulting low banks of broken material call for much moving, and give a low steam-shovel efficiency. Successful blasting under any given set of conditions, requires experience, for example, a given quantity of powder that will break a certain tonnage in one case may over or undershoot the same quantity in other conditions. The softer the rock usually the greater the blasting-charge necessary, as soft material tends to spring, while the harder rock will break with the same charge.

Much has also been written of the merits of different blasting-powders, many claiming that dynamite will fracture the rock finer. In blasting on a large scale this is not so. Were enough dynamite used to shatter the rock, the bank would be blown all over the steam-shovel bench. Dynamite, of course, does shatter more than

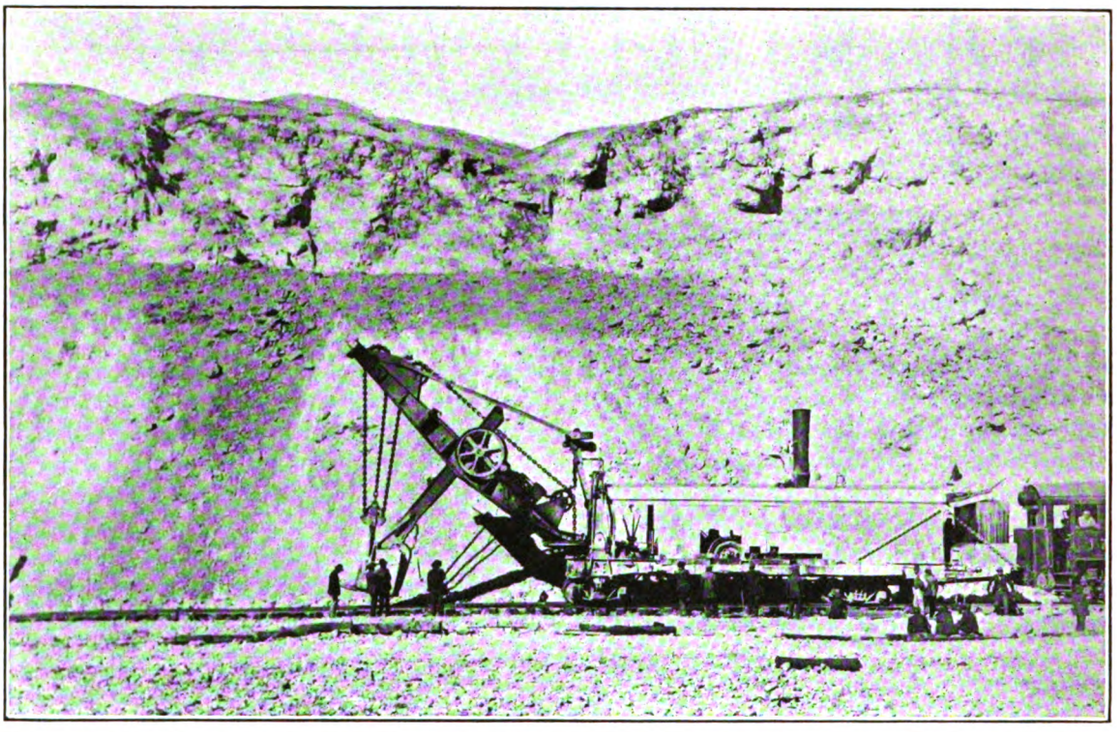

FIG. 1. SHOWING FINENESS OF ORE BROKEN IN BLASTING A BANK 160 FT. HIGH

black powder, on account of its rapidity, but only close to the blasting-charge. In calculating the charge to properly break a bank, practically the same conditions result, whether dynamite or black powder is used. Black powder for Chuquicamata was made at Calama, a town 15 miles distant. The ingredients used were, roughly, 75% sodium nitrate, 15% charcoal, and 10% sulphur. Extreme care was not used in this mixture, nor were the ingredients analyzed, but the powder was grained and glazed, and was most satisfactory. It cost, delivered at the mine, about 6c. per pound, and a given amount of 40% dynamite was equal in blasting-strength to about one and a half times the weight of the powder of local manufacture. Black powder was, all things considered, by far the most satisfactory, although many varieties and grades of explosives were tried. The commercial $NaNO_3$ used in this powder was as a rule rich in $KClO_3$. Higher-grade dynamites were used as a rule in drill-hole blasting, in order to get the most out of the pockets formed by springing, as previously stated. Recent

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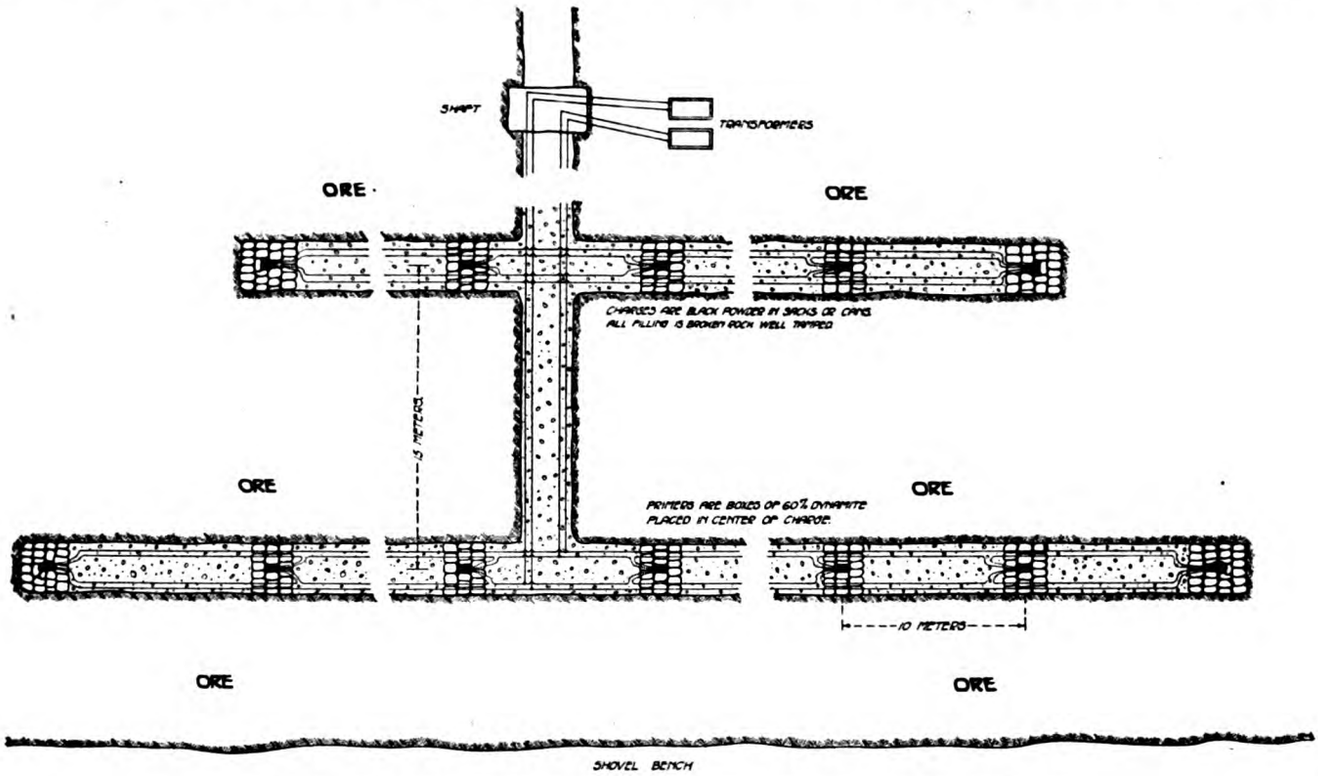
photographs of the Cornelia Copper Co.'s work on shallow banks, showing the many big boulders, are typical of many sections at Chuquicamata on similar heights of bank. The cost of breaking these boulders at the latter place, previous to the time of the installation of the coarse jaw-crushers, was as much as 5c. per ton, and even higher in exceptional cases. After the erection of the coarse crushers, which could take practically anything that could pass through the steam-shovel dipper, the costs for block-holing dropped below 2c. per ton.

It will be seen, from a study of the blasting plans, that as wide a range as from 400 to 1200 lb. of black powder was used per linear metre of line of least resistance. It was early demonstrated that the height of the bank was of little importance in calculating a blasting-charge, that is, if the line of shear was 50 ft., the blasting-charge would be approximately the same, whether the bank was 100 ft. high, or of indefinite height. A drift through a section of 'hog-back', with the same line of shear throughout, and with heights of 40 ft. at each side of the ridge, and 130 ft. in the centre, was loaded on a basis of cubic yards to be broken, in order to prove this principle. The result was that the centre of the blast, or the point under the high part of the ridge, was greatly overloaded, while the section of low-bank heights was properly broken. The resulting pile of broken rock formed a semi-circle, with a point under the highest part of the ridge taken as a centre. It was clear from this point that it was necessary to calculate on the line of least resistance only, and this practice was thereafter followed.

Owing to the variable conditions in the rock to be broken, no empirical formula could be devised, and it was only from blasting in certain sections that knowledge was gained as to what factors per metre of least resistance should be used. The cost of driving the drifts, 4½ by 6½ ft. in section, at Chuquicamata, varied from $10 to $20 gold per foot, with an average of $13. The ground being hard and dry, no timbering was required. Muck was trammed from the faces in buckets on trucks, and during the operation of loading the space between the blasting-charges was filled with run-of-mine by this equipment. The greater spacing of the drifts required a larger blasting-charge, which filled from 70 to 90% of the tunnel. No chambers were required to accommodate the blasting-charge, as the charges were loaded in the drifts themselves. The greater the space between the drifts, of course, the less cost per ton broken. In the beginning, it was useful to have the drifts spaced 15 m. only, so that, in case the blast were undershot, the drift immediately behind could be re-loaded, this time with an overload, and the material of both blasts knocked down successfully. This did not happen often, but it is well for the blaster to know his ground before adopting the maximum spacing. The factors per line of least resistance, on a 30-metre spacing, show an increase per metre over the factors for a 15-metre line of least resistance in the same ground. The loading of drill-holes on the basis of a given factor per foot in depth of hole, with the slope as a constant ratio, always gave good results, as the line of least resistance is proportionate to this height. Where the horizontal distance is uniformly two-thirds the vertical height, the factor per cubic metre works out well, and varies in this material from 1½ to 2½




GENERAL ARRANGEMENT OF BLASTING CHARGES AND ELECTRIC CONNECTIONS

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lb. per cubic metre to be broken, or 1⅛ to 1⅜ lb. per cubic yard.

After a blast by the tunnel-method, and before the miners are allowed to return to work in the blasting-tunnels that are in preparation, the helmet-crew, consisting of three men, one or more supplied with a bird in a cage, descend into the mines, and test all the drifts for bad air. The helmet-crew usually does not enter until 24 hours after the blast, and it is seldom found that gases entering the mine interfere with the work for a longer period than 48 hours. It is always well to maintain a regular helmet-crew to do nothing but act as a life-saving squad. They should have regular exercises and duties to perform daily, in connection with their work, and be always available at a moment's notice, because, in the case of a premature explosion, the great danger to the men underground would be from asphyxiation.

The springing of churn-drill holes is at best a most unsatisfactory procedure, as one is never certain that the pocket sprung is going to be large enough to accommodate the blasting-charge. If not large enough the powder will rise in the barrel of the hole. In the case of blasting at Chuquicamata, it was most essential to have a pocket of ample size, because, when the bottom could be successfully blasted, the top would take care of itself. In springing with 75% nitro-gelatin, which is the best explosive found for this work, from 12 to 15% of the weight of the full blasting-charge as a rule was used to spring the pocket. So much has been written about springing holes that I need make no comment here other than to say that the quantities used in springing holes usually increase in multiples of three, when the chamber is springing as it should. Where the collars of the drill-holes are likely to blow out, and where the ground is soft, and manifests a tendency to cave, it is often best, where the blaster has plenty of time, to use sand instead of water, and to fill the hole each time. This is costly, as the drill has to be placed over the hole each time to clean out the sand from both the hole and the pocket. Where the springing of drill-holes is in good ground, and where water can be used successfully for tamping, the usual rule is to use a gallon of water per pound of springing-charge, the quantities to be varied afterward according to the results obtained. By the use of a mirror to reflect the sunlight to the bottom of the hole, and by means of the tamping-dolly, which consists of a piece of round wood 36 to 40 in. long, tied preferably to a piece of window-cord, the blaster soon learns, within reasonable limits, whether or not he will be able to 'chamber' the charge in the pocket. When a hole gives trouble—and there are few that do not—the blaster tries to make up the difference in the blasting-powder necessary in the two adjacent holes. This invariably leaves a hard bottom for the shovel to work against, thereby seriously interfering with efficiency in loading. Sometimes the pocket formed by springing a hole is found to be too small for the calculated charge and the blaster can place only 1000 lb. when 5000 lb. was intended.

## Industrial Progress

### METHODS OF EXCLUDING WATER FROM OIL-WELLS*

In most of the oilfields water is found in the formations overlying the oil-sands. There are a number of methods in use for excluding this water from the wells. Local conditions must be considered in the choice of method for any particular well. Shallow wells are often successfully handled by landing the casing in impervious strata, but for deep drilling in California hydraulic cement is generally used.

Formation shut-off is the term applied to a shut-off where casing is landed in a bed of shale or clay without using cement or other device to plug the space between the casing and the wall of the hole. Much depends upon the kind of casing shoe used. It should be a plain shoe, as distinguished from the notched Baker shoe and from the types used in rotary drilling. A shoe 14 to 20 in. long is generally used. In order to drive the shoe tightly into the material, the smaller diameter should be at the bottom. When a suitable shale or clay is reached for landing the water-string, the hole is drilled ahead with a smaller-sized bit and the casing is driven until the shoe is tight. This will prevent the water from following down the outside of the casing and entering the well.

At the first departure from the simple formation shut-off, clay and chopped rope were used to fill and seal the space between the shoe and the wall. A practice in favor before the introduction of cement, but now obsolete, was to make a landing on a hard lens or 'shell', as it is usually called, depending on a bag of flaxseed to seal the space around the shoe. The hole was carefully 'trued up' and the cuttings removed, then the seed-bag was lowered into the hole and the casing landed on it. The swelling of the seed was expected to hold back the water long enough to allow the mud and other material to settle and make a permanent job.

Tamping is a method which has been in use a number of years but which now has but few followers. A complicated expanding-packer is put on the oil-string where it is desired to make a shut-off. This point, however, must also be below the next larger string of pipe. The packer is made of canvas and might be described as an inverted umbrella. Sand and pulverized shale is then washed between the casings by means of a stream of water. The outer string must be moved up and down all the time, both to keep the material introduced moving to the bottom of the hole and to tamp it around the shoe. As the space below fills, the tamping-string is removed joint by joint. This operation takes from three to six weeks. By this means a string of casing is saved, the last string serving as both the oil and water string. A few men advocating the practice claim that the casing recovered repays the labor involved. The process is applicable only in drilling where formations stand up sufficiently to allow the removal of casing at will.

Hydraulic cement is generally used in California for excluding water from oil-sands. What is called the 'dump-bailer' method is the simplest in use. The hole is first 'trued up' and cleared of cuttings if the work is done at the bottom of the hole. If the hole has already been carried below the shut-off point it is necessary to place a bridge, or, in other words, a false bottom in the hole. The casing is raised off the bottom. From 30 to 40 sacks of cement, mixed to the consistence of thin gruel, are lowered to the bottom by means of the dump-bailer. The casing is then filled with water to the top and a cap screwed on it.

*Abstract from Second Annual Report of the California State Oil and Gas Supervisor.

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When the string is lowered to bottom, the cement is forced behind the casing. Time is allowed for the cement to set, after which any that has been left in the hole is removed by drilling. One of the advantages of this method is that where mud has been used in drilling, this mud can be left behind the casing. It is the usual practice in some fields to put in a few barrels of clear water in advance of the cement, so as to give it a better chance to set without being mixed too much with mud. In experienced hands this method has shown a large proportion of successful shut-offs, even in deep territory. The amount of cement used is necessarily limited and consequently the method is applicable only to cases where there are no large cavities to be filled.

Pumping cement by pressure-pumps is the method in most general use. For this purpose complete outfits are mounted on motor trucks and steam-connections are made with the boiler at the well. Two pumps are commonly used. The work is generally started with a pump capable of delivering a pressure of 300 to 400 lb. and finished with one capable of 700 to 800 lb. per square inch. The cement is mixed in a portable trough. Neat cement is used, mixed to the consistence of thin gruel. It is important to 'true up' the bottom of the hole and remove the cuttings. The casing is raised a few feet from the bottom while the cement is being pumped and is then lowered to position after the cement is in place. Some operators circulate water before pumping the cement until the clear water comes to the surface outside the casing. Others leave as much circulated mud in the hole as possible, pumping only a small amount of clean water in advance of the cement in order to prevent the mud mixing with the cement, the idea being to leave this mud to settle around the casing and thus prevent the movement of water from one stratum to another.

An early method, now little used, was to pump cement through tubing, a packer being placed at the bottom of the casing to prevent the return of the cement between the tubing and the casing. An improvement on this method, now extensively used, is to pump the cement through tubing passing through a casing-head. The casing-head is provided with a release and is fitted to the top of the water-string. The tubing is lowered within a few feet of the casing-shoe, the distance depending on the amount of cement it is desired to leave in the casing. Water is pumped to get circulation outside the casing. Then the casing-head release is opened and the casing pumped full of water, which prevents the cement from coming up between the tubing and the casing and forces it outside the casing. The release is then closed. After the cement is pumped and displaced from the tubing with water, the casing is lowered in place and all connections closed until the cement has taken its initial set. This is in order to prevent a possible return of the cement around the shoe. There are two methods of determining when the cement has been displaced from the tubing. The first is to calculate the capacity of the tubing and measure the required amount of water. The second method is to reduce the diameter of the lower end of the tubing with a swedge-nipple. A wooden plug follows the cement ahead of the displacing water. When the plug reaches the swedge-nipple and the cement is out of the casing, the pump-pressure rises and the circulation stops. Most operators pump the cement directly into the casing and then displace it and force it behind the pipe by filling the pipe with water. Some operators compute the contents of the casing and stop the pumps when the calculated amount of water has been pumped.

In another method two wooden plugs about three feet long are used. They are made to fit tightly against the casing by means of rubber belting. The plugs are introduced by a special arrangement of gates and fittings. The first plug is started down the casing ahead of the cement to prevent mixing of the water and cement. The usual practice is to raise the casing about 18 in. so that the upper part of the first plug remains in the casing. Sometimes a wooden 'spreader', 2 by 4 in. by 6 ft. to 15 ft. long is used ahead of the second plug. This retains within the casing cement which has become excessively diluted and would otherwise rest at the critical position around the shoe of the casing. The plugs and 'spreader' are easily removed by drilling. The second plug is introduced after the cement is pumped and the casing lowered so that the plugs and 'spreader' will not be passed out of the casing but will come to rest and thus increase the pressure of the pumps when all the cement has left the casing. In using this process it is customary to measure the water pumped behind the second plug as a check on its progress.

The amount of cement used varies from five to thirty tons, according to local conditions. On an ordinary job, without any complications from caving, ten to fifteen tons is used. Most operators use larger quantities than would be needed for the simple purpose of plugging off water behind the shoes, because the cement serves to reinforce the casing by filling the space between the casing and the wall and also prevents corrosion from mineral waters. It is not uncommon to find in re-drilling or abandonment of wells where large amounts of cement have been used, that the cement has followed up the casing as much as 1000 feet.

Shutting-off 'bottom-water' is a different problem, and usually a much more difficult one than shutting-off 'top-water'. The hole must first be cleaned and, if any casing was left in the hole when the oil-string was pulled, it must be shattered with dynamite and plugged above the water-sand. Some operators put in rope, brick, etc., and tamp thoroughly with the tools and on top of that, as a foundation, tamp a mixture of cement and lathe-cuttings used dry in tin cartridges. These are broken and the cement mixed with water in the hole by the tools. Others simply dump neat cement with a dump-bailer as far to the bottom as the lowest oil-sands.

Probably the best method, and the one that has met with success under the most difficult conditions, is pumping the cement through tubing. The outfit is similar to that described above for cementing a water-string with the tubing and casing-head. In addition the space between the oil and water-strings is packed at the top of the water-string, thus preventing the cement from rising between these two casings.

The most difficult problem is where there is a water-sand between oil-sands, and it is desired to produce from the lower oil-sand and give the upper oil-sand the proper protection from water. Usually this requires two additional strings of casing, the original oil-string being cemented above the water sand, one additional string being cemented below the water-sand, and one additional string for the lower oil-sand.

## Book Review

**The Vaporizing of Paraffin for High-Speed Motors (Electric Ignition Type).** By Edward Butler. Pp. 117. Ill., index. Charles Griffin & Co., London, and J. B. Lippincott Co., Philadelphia. Price, $1.50.

Paraffin in British usage, as most of our readers will remember, is the word applied to approximately the same distillate of petroleum that is called kerosene in America. Gasoline has become so expensive and so difficult to obtain at any price in England that the demand for a kerosene-carbureter is even more insistent than it is in America. The present volume discusses the carbureters for gasoline and the modifications necessary in order to construct a kerosene-carbureter. The author has apparently made a careful

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study of his subject. However, the book is so carelessly written and the style is so involved that we do not believe many persons will have the patience to dig out the facts that the text doubtless contains. A fair example of the general style is furnished by one sentence that contains 124 words, including three clauses introduced by 'which', and one by 'and this'. The book's usefulness for the American reader is further impaired by the fact that British technical terms and names for the various petroleum distillates are used entirely, and no glossary is provided. In short the book is an excellent example of what a technical treatise should not be.

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**Elements of Electrical Engineering.** By William S. Franklin and William Esty. Volume II. Alternating Currents. Pp. 408. Ill., index. The Macmillan Co., New York. For sale by 'Mining and Scientific Press', San Francisco. Price, $3.50.

As the title-page states, this is a text-book for technical schools and colleges. Few engineers in other lines than electrical work will care to make as much of a study of the subject as this book would require nor is it likely that the practising electrical engineer will care to have it as a reference book. For the purpose for which it was intended, however, the book is entirely satisfactory. Some of the chapter-headings are: The Alternator, Alternating Current Measurements, Harmonic Electromotive Force, Complex Quantity, The Polyphase System, Voltage and Voltage Regulation, The Synchronous Motor, The Transformer, The Induction Motor, The Single-Phase Series Motor, Switchboards, and Transmission Lines. The book is well illustrated and the authors have done their best to explain a difficult subject.

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**Second Annual Report of the State Oil and Gas Supervisor of California.** Pp. 404. Ill., index. California State Mining Bureau, San Francisco.

The first part of this report is a so-called 'letter of transmittal' of 121 pages, and includes a general discussion of the work of the department, a copy of the law establishing the department, township-plats showing the area assessed for the work, and several brief discussions of special problems of oilfield development. Then follow separate reports by the four deputy supervisors on the work in their departments, including a summary of decisions rendered. A directory of oil companies and operators, together with brief information regarding capitalization and number of producing wells, is included. The report is nominally for the fiscal year 1916-1917, but some parts of the report have been brought up to December 1, 1917, while the data in the directory is corrected to December 31, 1916. While the delay in publication was presumably unavoidable, it is unfortunate that all parts of the report were not brought to approximately the same date. However, the report, like its predecessor, will be of great value to those interested in any branch of the oil industry.

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**Modern Management Applied to Construction.** By Daniel J. Hauer. Pp. 187. Ill., index. McGraw-Hill Book Co., Inc., New York. For sale by 'Mining and Scientific Press', San Francisco. Price, $2.50.

Although many of the investigations in connection with so-called scientific management have been made with regard to construction work, the fact remains that most construction work is not managed scientifically. This is largely because many contractors have risen from the ranks and have had, or at least have thought they had, little time for studying either technical literature or other contractors' methods. The author of the present volume, as a successful contractor, is in a favorable position to show the advantages of scientific management as applied to construction. While it is possible that in some respects his enthusiasm runs away with him, the case for study and planning is, in the main, well stated. Financial arrangements and the choosing of construction plant are discussed. One entire chapter is devoted to shovels and shoveling to show the importance of apparently small details. Plant lay-outs and bonus systems are also considered. The book will be of value to both contractors and engineers. Its usefulness could, however, have been increased considerably by the use of a larger number of well-chosen illustrations and by the application of scientific methods of arrangement to the text of the book itself.

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**Ports and Terminal Facilities.** By Roy S. MacElwee. Pp. 309. Ill., index. McGraw-Hill Book Co., Inc., New York. For sale by 'Mining and Scientific Press', San Francisco. Price, $3.

The importance of proper terminal facilities, particularly at ports, is becoming more and more apparent. The present volume, without attempting to discuss technical details of construction, gives a general view of the entire subject. After a brief introductory chapter, the leading ports of the world and the general characteristics of a well co-ordinated seaport are described. Competition between ports for rail and maritime freight is shown to be mainly dependent on rates and they in turn on many conditions. Transfers of freight by belt-line railroads and by lighters are then discussed. The American and particularly the Western reader will be surprised at the importance given to lighters not only for transfer between vessels but also between vessels and factories, and even between factories. Drays and motor trucks are then considered, together with methods for avoiding congestion of deliveries. Piers, wharves, quays, and wharf, shed, and warehouse equipment are discussed, together with methods of handling special kinds of freight. Chapters are devoted to inland waterways, industrial-harbor development, and free ports, with particular attention to the free ports of Bremen and Hamburg. A bibliography is also given. The book is well illustrated and the treatment throughout is non-technical.

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**Principles of Iron Founding.** By Richard Moldenke. Pp. 494. Ill., index. McGraw-Hill Book Co., Inc., New York. For sale by 'Mining and Scientific Press', San Francisco. Price, $4.

This is probably the most complete book upon the subject that has appeared in English. After a brief historical introduction the industrial and financial status of the foundry is considered, together with foundry organization and management. The next chapter deals with the metallurgy of iron and the effect of the various impurities upon it. The various processes for making both wrought and cast-iron are then considered. The next chapter discusses the properties of cast-iron, after which the various kinds and the recommended composition of each are discussed. Foundry raw materials including metals, fuels, fluxes, refractories, facing and parting materials, and core-binders are then considered. The next chapters deal with the technology of combustion and with melting processes. Then comes a discussion of mixture-making and of testing cast-iron. There is a glossary of terms and an appendix containing specifications and directions for various physical and chemical tests. The book is well-illustrated and the treatment is as nearly non-technical as is possible considering the subject.

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**Elements of Fuel Oil and Steam Engineering: A Practical Treatise Dealing with Fuel Oil for the Central-Station Man, the Power-Plant Operator, the Mechanical Engineer, and the Student.** By Robert Sibley and Charles H. Delany.

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Pp. 320. Index, illustrated. Technical Publishing Co., San Francisco, 1918. For sale by the 'Mining and Scientific Press.' Price, $3.

The treatment of the subject justifies the title of the book. It gives an account of every practical detail of the equipment with which the fuel engineer will have to deal in his daily work. It does not assume familiarity with this equipment, and lead the student into a consideration of the higher principles, and in this respect it will be of extreme value to the student and to the operator who will find it a guide to the things that are assumed as already known by the writers of more advanced text-books. The senior author is now the editor of the 'Journal of Electricty,' and the junior author is a steam-power plant specialist in active practice in the handling of large and complicated operations. The sub-headings treated include the fundamental laws involved in fuel-oil practice, theory of pressures, measurement of temperatures, elementary laws of thermodynamics, steam-tables in fuel-oil practice, computing boiler horse-power, equivalent evaporation and factor of evaporation, the steam calorimeter and its use in fuel-oil practice, rational and empirical formulas for steam constants, the boiler shell and its accessories for steam generation, boiler classification in fuel-oil practice, specifications for purchase of fuel-oil, heating value of oils, taking of boiler-test data, heat-balance and boiler-efficiency, and so on. It is eminently practical.

## Personal

**Taggart Aston** has been appointed port engineer of Everett, Washington.

**J. R. Nevins** will have charge of construction of dwellings for employees at the Puget Sound Navy Yard.

**H. T. Cory** has returned to Washington, D. C., where he will probably make his headquarters until after the War.

**Lorin A. Handley,** president of the Board of Public Works of Los Angeles, has been commissioned major in the Quartermaster Corps.

**Louis Bonneau,** chief of the Board of Public Works of French Indo-China, was in San Francisco recently on his way back to Indo-China from the western front.

**J. N. Mahoney,** formerly of the engineering department of the Westinghouse Electric & Manufacturing Co., has resigned to open consulting offices in New York.

**Eugene S. Zack,** who was sent to the United States in May 1917 by the Kerensky government to study American highways and transportation facilities, was in San Francisco recently.

**H. F. Moore,** of the Engineering Experiment Station of the University of Illinois, has been appointed chairman of a committee to investigate the fatigue phenomena of metals for the National Research Council.

The changes caused by the re-organization of the railroads under Government supervision in the western district include the appointment of **C. J. McDonald,** formerly assistant superintendent of transportation for the Southern Pacific Co. as assistant to the district director, **Charles S. Fee** as passenger-traffic manager for the combined Southern Pacific-Western Pacific, **G. W. Luce** as freight-traffic manager, **Guy Shoup** as counsel, and **J. Q. Barlow** as chief engineer.

## Obituary

**George W. Dickie** died suddenly at his home in Oakland, August 17. He was born at Arbroath, Scotland, July 17, 1844. He received his early training in the shops of the North British Railroad Co. and in his father's shipyard. In 1869 he came to San Francisco, becoming engineer for the Risdon Iron Works the following year. This position he held until 1883, when he became manager for the Union Iron Works. In 1905 he severed his active connection with the Union Iron Works and opened consulting offices in San Francisco. During the few months immediately preceding his death he acted as resident manager for the Moore Shipbuilding Co., of Oakland. Mr. Dickie designed and built a large part of the pumping and other machinery used in the mines of the Comstock Lode. Some of the more important vessels constructed for the U. S. Navy at the Union Iron Works under his direction were the battleships 'Oregon', 'Wisconsin', and 'Ohio', and the cruisers 'Colorado', 'Olympia', and 'South Dakota', besides many ships for private owners. Mr. Dickie was one of the founders and for some time the president of the Technical Society of the Pacific Coast. He was also a member of the American Society of Mechanical Engineers, the American Society of Naval Architects and Marine Engineers, and the California Academy of Sciences and had served as vice-president of the two first-named organizations. He was the author of 'Pumping and Hoisting Works' and of many papers and other contributions to the proceedings of technical societies. In 1873 Mr. Dickie married Miss Anna Jack, who survives him, together with one daughter, Miss Anna Belle Dickie, and five sons, William S. Dickie, head of the drafting department at the Mare Island Navy Yard, Alexander J. Dickie, a farmer, George W. Dickie, Jr., of the Alameda plant of the Bethlehem Shipbuilding Corporation, James S. Dickie, of the American Shipbuilding Co., of Cleveland, Ohio, and Frederick M. Dickie, editor of the Pacific Marine Review.

**J. W. French,** State manager for the Austin-Western Road Machinery Co., with headquarters at San Francisco, died at San Francisco, August 15.

## Commercial Paragraphs

**The Aberthaw Construction Co.,** of New York, has opened a branch office in the Hobart Bdg., San Francisco.

**The Austin Manufacturing Co.** has issued a 64-page illustrated catalogue describing the motor road-rollers and other road machinery manufactured by the company.

**The Bastian-Blessing Co.,** of Chicago, Ill., has issued a catalogue describing the Rego welding and cutting apparatus, using either oxygen and acetylene or oxygen and hydrogen.

**C. F. Braun & Co.,** of San Francisco, have completed a brick erecting-shop and have commenced the construction of a plate-shop and storage-shed at their factory.

**J. H. Fenton** has been appointed manager of the industrial division of the Los Angeles office of the Westinghouse Electric & Manufacturing Co., which includes jurisdiction over the Tucson and El Paso offices.

**The Westinghouse Electric & Manufacturing Co.** has issued catalogue 3-B, a 104-page bulletin describing the switchboard, portable, and precision instruments, ammeter shunts, instrument transformers, and relays manufactured by the company.

Many orchardists and tree-surgeons have found that the best and most economical way of treating tree-wounds of all kinds is to cover them with roof-paint. It is easy to apply and farmers throughout the country have used it with benefit in the treatment of abrasions and cuts, and when grafting. It is heavy enough in body to form a thick coating over the wound, thus preventing insects and the elements from harming the tree. It is also very easy to apply. A professional tree-surgeon and pruner that is taking care of 20,000 trees recommends **Oronite roof-paint.** This paint is the best for healing abrasions of trees.

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# Market Prices

### Iron and Steel Products

(Prices August 22, f.o.b. Pittsburgh, unless otherwise noted)

| | |
|---|---|
| Bessemer pig-iron, per ton | $36.60 |
| Basic pig-iron, per ton | 33.40 |
| No. 2 foundry pig-iron, 1.75 to 2.25% silicon, per ton | 34.40 |
| Malleable, per ton | 34.90 |
| Bessemer steel billets, per ton | 47.50 |
| Bessemer sheet bars, per ton | 51.00 |
| Open-hearth steel billets, per ton | 47.50 |
| Open-hearth sheet bars, per ton | 51.00 |
| Steel bars, per 100 lb | 2.90 |
| Iron bars, Cleveland, per 100 lb | 3.64 |
| Beams, per 100 lb | 3.00 |
| Tank-plates, per 100 lb | 3.25 |
| Sheets, black, No. 28 gauge, per 100 lb | 5.00 |
| Sheets, blue annealed, No. 10, per 100 lb | 4.25 |
| Sheets, galvanized, No. 28, per 100 lb | 6.25 |
| Wire nails, per 100 lb | 3.50 |
| Plain wire, per 100 lb | 3.25 |
| Galvanized wire, per 100 lb | 3.95 |
| Barbed wire, painted, per 100 lb | 3.65 |
| Structural rivets, per 100 lb | 4.40 |
| Boiler rivets, per 100 lb | 4.50 |
| Cast-iron pipe, class A, 4-in., Birmingham, per ton | 59.00 |
| Cast-iron pipe, class B, 4-in., Birmingham, per ton | 58.00 |
| Cast-iron pipe, class A, 6-in. and over, Birmingham, per ton | 56.00 |
| Cast-iron pipe, class B, 6-in. and over, Birmingham, per ton | 55.00 |
| Freight rates, iron and steel finished products, Pittsburgh to Pacific Coast points, carloads, per 100 lb. | 1.25 |
| Ferro-manganese, 70%, New York, per ton | 250.00 |

### Iron and Steel Scrap

(Maximum base-price f.o.b. consuming point, established by Iron and Steel Institute for quarter commencing July 1)

| | |
|---|---|
| No. 1 heavy melting-scrap, per ton | $29.00 |
| Cast-iron borings and machine-shop turnings, per ton | 19.00 |
| No. 1 railroad wrought, per ton | 34.00 |

### Fuel-oil, Asphaltum, and Bituminous Products

(Prices f.o.b. San Francisco, August 28)

| | |
|---|---|
| Fuel-oil, 14 gravity, in bulk, per barrel | $1.60 |
| Calol fuel-oil, 24 gravity (diesel-engine), in bulk, per barrel | 1.85 |
| Fuel-oil, 27 gravity, in bulk, per gallon | 0.05 |
| Calol paving asphaltum, D grade, in tank-cars, per ton | 13.00 |
| Calol paving asphaltum, D grade, in barrels, per ton | 16.50 |
| Calol paving asphaltum, E and L grades, in tank-cars, per ton | 12.75 |
| Oronite bituminous priming paints, in barrels, per gallon | 1.00 |
| Oronite roof-paint, in barrels, per gallon | 0.50 |
| Shingle-oil, in barrels, per gallon | 0.215 |
| Aroturps, in barrels, per gallon | 0.245 |

### Cement

(Prices f.o.b. San Francisco, August 28)

| | |
|---|---|
| Portland cement, in sacks, carload lots, per barrel. | $2.88 |

Subject to $0.05 per barrel cash discount and rebate of $0.10 each for sacks returned

### Explosives

(Prices f.o.b. Giant, August 28, and subject to 2% cash discount)

| | |
|---|---|
| 40% nitro-glycerin, carload lots, per 100 lb | $22.75 |
| 40% nitro-glycerin, ton lots, per 100 lb | 25.25 |
| Judson powder, 20%, carload lots, per 100 lb | 18.25 |
| Judson powder, 20%, ton lots, per 100 lb | 20.75 |
| Giant stumping-powder, 20%, carload lots, per 100 lb. | 15.00 |
| Giant stumping-powder, 20%, ton lots, per 100 lb. | 17.50 |
| Black powder, 100-keg lots, per keg | 2.30 |
| Black powder, carload lots, per keg | 2.00 |
| 'Blue-label' safety-fuse, less than 6000-ft. lots, per 1000 ft. | 8.45 |
| No. 6 blasting-caps, 1000 to 20,000 lots, per 1000. | 16.66 |
| No. 8 blasting-caps, 1000 to 20,000 lots, per 1000. | 27.16 |
| No. 6 electric blasting-caps, 10-ft. wires, less than 1000 lots, per 100 | 12.92 |

### Non-Ferrous Metals

(Prices f.o.b. San Francisco, August 28)

| | |
|---|---|
| Antimony (wholesale), per lb | $0.15 |
| Copper, electrolytic, carload lots, per lb | 0.26 |
| Copper, electrolytic, small quantities, per lb | 0.2735 |
| Lead, pig, per lb | $0.083 to 0.093 |
| Spelter, per lb | 0.11 |

### Lumber

(Mill prices per M.B.M. on douglas fir established by Fir Production Board)

Fir Common Boards, S1S or Shiplap

| | |
|---|---|
| 1× 2—6 to 20 ft. mixed lengths, S1S | $20.00 |
| 1× 3—6 to 20 ft. mixed lengths S1S | 20.00 |
| 1× 4—6 to 20 ft. mixed lengths S1S | 18.00 |
| 1× 6—6 to 20 ft. mixed lengths S1S or shiplap | 18.50 |
| 1× 8—6 to 20 ft. mixed lengths S1S or shiplap | 19.50 |
| 1×10—6 to 20 ft. mixed lengths S1S or shiplap | 19.50 |
| 1×12—6 to 20 ft. mixed lengths S1S or shiplap | 20.00 |

For selected common, add $3; for dressed and matched, add $1.50; for grooved roofing, add $3; for 16, 18, and 20 ft. only, add $2. Other orders for specified lengths, add $1 to above prices. No. 2 common boards and shiplap, $3 less when in stock.

Fir Common Dimension S1S1E

| | 6 ft. | 8, 12, 14 ft. | 16 ft. | 9, 10, 18, 20 ft. | 22, 24 ft. | 26 to 32 ft. |
|---|---|---|---|---|---|---|
| 2× 3, 2× 4 | $17.50 | $18.50 | $19.50 | $20.50 | $21.50 | $23.50 |
| 2× 6, 2× 8 | 17.50 | 18.00 | 19.00 | 19.50 | 20.50 | 22.00 |
| 2×10 | 18.00 | 19.00 | 19.50 | 20.00 | 21.00 | 23.00 |
| 2×12 | 18.50 | 19.50 | 20.00 | 20.50 | 21.50 | 23.50 |
| 2×14 | .... | 21.00 | 21.00 | 22.00 | 23.00 | 25.00 |
| 2×16 | .... | 22.00 | 22.00 | 23.00 | 24.00 | 26.00 |
| 2×18 | .... | 24.00 | 24.00 | 25.00 | 26.00 | 28.00 |
| 2×20 | .... | 26.00 | 26.00 | 27.00 | 28.00 | 30.00 |

Add $0.50 for every 2 ft. over 32 ft. up to 40 ft. For select common, add $3; S1E or rough, same mill base as dressed. For 2×4, 2×6, or 2×8 dressed and matched or shiplap, add to S1S1E, $1.50. Hemlock permitted in 2×4 and 2×6.

Fir Common Plank and Small Timbers S1S1E or S2S

| | 8, 12, 14, 16 ft. | 9, 10, 18, 20 ft. | 22, 24 ft. | 26–32 ft. |
|---|---|---|---|---|
| 3× 3, 3×4 | $21.00 | $21.50 | $22.50 | $24.50 |
| 3× 6 | 22.00 | 22.50 | 23.50 | 25.50 |
| 3× 8 | 22.00 | 22.50 | 23.50 | 25.50 |
| 4× 4, 4×6, 4×8 | 22.50 | 23.50 | 24.50 | 26.50 |
| 6× 6 to 8×8 | 22.00 | 23.00 | 24.00 | 26.00 |
| 3×10, 3×12 | 23.50 | 24.50 | 25.50 | 27.50 |
| 3×14 | 24.00 | 25.00 | 26.00 | 28.00 |
| 3×16 | 25.00 | 26.00 | 27.00 | 29.00 |
| 3×18 | 27.00 | 28.00 | 29.00 | 31.00 |
| 3×20 | 29.00 | 30.00 | 31.00 | 33.00 |
| 4×10, 4×12 | 23.50 | 24.50 | 25.50 | 27.50 |
| 4×14 | 24.50 | 25.50 | 26.50 | 28.50 |
| 4×16 | 25.50 | 26.50 | 27.50 | 29.50 |
| 4×18 | 27.00 | 28.00 | 29.00 | 31.00 |
| 4×20 | 29.00 | 30.00 | 31.00 | 33.00 |

Add $0.50 for every 2 ft. over 32 ft. up to 40 ft. For select common, add $3; S1E or rough, same mill base as dressed.

### Coal

(Utah and Wyoming mine prices per ton fixed by the U. S. Fuel Administration)

| | |
|---|---|
| Run-of-mine | $3.00 |
| Prepared sizes | 3.65 |
| Slack or screenings | 1.85 |

Freight-rates, Utah and Wyoming mines to San Francisco, carloads, $5.65 plus $0.15 war-tax per ton.

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# Construction News Summary

## STREET AND ROAD WORK

**Bakersfield, Cal.**—Contract for improvement of Flower street has been awarded to F. W. Nighbert, Bakersfield, at $0.035 per sq. ft. for grading, tamping, and rolling, $0.35 per ft. for concrete curbs, and $0.13 per sq. ft. for concrete sidewalks, a total of $2008.

**Bisbee, Ariz.**—Bids will be received until September 14 by County Highway Commission for construction of highway from Douglas to Bisbee. Work will be divided into two sections.

**Carson City, Nev.**—Date of receiving bids for state highway work in Washoe county, which was to have been August 20, has been postponed indefinitely because of legal technicality.

**Eureka, Cal.**—Contracts for construction of Bull Creek-Mattole road have been awarded as follows: section No. 1, Poland & Moore, $21,700; section No. 2, E. J. Etter, $18,530; section No. 3, L. H. Roscoe, $19,230. Each section is a little less than six miles long.

Board of Supervisors has made agreement with Federal authorities that will ensure construction of highway along Trinity river from Hoopa to Weitchpec, seven miles. Estimated cost is $30,000.

**Everett, Wash.**—Wright & Bancroft were low bidders for paving the Lake Stevens road at $55,449.60 for the first three-mile division and $58,051.75 for the second three-mile division. Kaiser Paving Co. bid $60,071.25 and $63,995.10.

**Fairfield, Cal.**—B. J. Finch, engineer for the U. S. Office of Public Roads, is preparing a report on the highways of Solano county.

**Holbrook, Ariz.**—Contract for improvement of 3½ miles of the Holbrook-Snowflake highway has been awarded to Rogers Bros., Snowflake, for $7102; other bidders were Turley & Tawner, $8215; J. P. Richards, $8655.

**Hoquiam, Wash.**—A. J. McGarry, Seattle, was the only bidder at $8000 for grading and filling Cherry street.

**Klamath Falls, Ore.**—Contract for construction of one mile of oil-macadam highway from end of 6th street toward Klamath basin has been awarded to J. H. Garrett, Klamath Falls, at $1.42 per square yard.

**Los Angeles, Cal.**—Fairchild-Gilmore-Wilton Co., Los Angeles, was low bidder for improving streets in the Second Street improvement district at San Pedro at the following unit prices: excavation, $1.09 per cu. yd.; bitulithic pavement, $0.218 per sq. ft.; grading, rolling, and oiling, $0.055 per sq. ft.; concrete curbs, $0.45 per ft.; concrete sidewalks, $0.14 per sq. ft.; concrete gutters, $0.20 per sq. ft.; granite-block gutters, $0.50 per sq. ft.; a total of $410,000. George H. Osward bid $425,000 and Bryant & Austin, Inc., slightly more.

Contract for construction of 5.92 miles of disintegrated granite highway from Lancaster east has been awarded to Fred Hoffman, Long Beach, for $50,000. Other bidders were Rogers Bros. Co., $51,900; George H. Oswald, $54,750; George R. Curtis, $59,700; Fred Osburn, $60,000.

**Martinez, Cal.**—Bids will be received until September 16 by Board of Supervisors for grading five miles of division No. 10 of the county highway system from Martinez by way of Franklin canyon to Barry hill.

**Modesto, Cal.**—Plans for improvement of several streets have been adopted and call for bids will be issued soon. Estimated cost is $36,707.

**Montesano, Wash.**—Contract for grading and paving highway near Elma including overhead crossing over Northern Pacific Railroad has been awarded to Haukeli, Hagg & Co., Aberdeen, for $23,960.

**Oakland, Cal.**—Contract for improvement of parts of Fleming avenue and Birdsall avenue has been awarded to Hutchinson Co., Oakland, at the following unit prices: grading, 6.5c. per sq. ft.; concrete curbs, 40c. per ft.; concrete gutters, 15c., oil-macadam pavement, 10c. per square foot.

Contract for improvement of highway from Decoto through Centerville to Irvington, 5 miles, has been awarded to Bates & Borland, Oakland, for $103,580. Other bidders were Blanchard-Brown Co., $110,499.10; Federal Construction Co., $113,207; Clark & Henery Construction Co., $116,499.

**Olympia, Wash.**—Contract for construction of 8½ miles of the Sunset highway in Lincoln county between Creston and Wilbur has been awarded to G. L. Stickler, Colton, for $65,696. Engineers' estimate was $65,758.

**Portland, Ore.**—State Highway Commission has awarded contracts for grading 9.55 miles of the Elgin-Minam road and 6 miles of the Union-Telocasset road to the officials of Union county, bidding in the name of the county, at $37,410 and $27,848. These figures are considerably less than the next lowest bids.

**Redwood City, Cal.**—Contract for repairing and oiling the La Honda road has been awarded to A. H. Kopperud, Oakland, for 1.75c. per sq. ft. Western Construction Co. bid 1.93 cents.

**Reno, Nev.**—U. S. Office of Public Roads has approved the following projects for construction of highways in Nevada under the Federal Aid Road Act: Reno to Huffaker, Tonopah to point 17 miles north-east, and Lovelock to point 17 miles east.

State Highway Department has appropriated $20,000 and the Lincoln Highway Association the same amount for highway construction in Lander, Eureka, and Churchill counties.

**Roseburg, Ore.**—No bids were received for construction of the Camas Valley road and work will be done by day-labor.

**Sacramento, Cal.**—J. E. Johnston, Tracy, was low bidder for construction of 14.9 miles of state highway between Merced and the easterly boundary of Merced county at the following unit prices: ordinary excavation, $0.90 per cu. yd.; borrow excavation, $1.05 per cu. yd.; 12-in. corrugated pipe, $1 per ft.; 18-in. pipe, $1.20; 24-in. pipe, $1.50; concrete in culverts and monuments, $16 per cu. yd.; concrete in pavement, $6 per cu. yd.; moving and re-setting property-fences, $150 per mile; guard-rail, $1 per ft.; monuments, $2 each; a total of $123,926.60. C. H. Laiblin bid $129,841 and George R. Daley, $151,739. Engineers' estimate was $97,281.95. State will furnish reinforcing steel, corrugated pipe, cement, sand, and coarse aggregate, valued at $62,727.85.

Clark & Henery Construction Co., Sacramento, was the only bidder for construction of 2.8 miles of state highway through the towns of Rocklin and Penryn at the following unit prices: excavation, $1.50 per cu. yd.; 24-in. corrugated pipe, $2.50 per ft.; concrete in culverts and monuments, $20 per cu. yd.; concrete in pavement, $6.90 per cu. yd.; guard-rail, $1 per ft.; monuments, $2 each; a total of $31,328. Engineers' estimate was $19,083.68. State will furnish reinforcing steel, corrugated pipe, cement, sand, and coarse aggregate, valued at $15,389.40.

Raisch Improvement Co., San Francisco, was low bidder for construction of asphalt wearing surface on state highway through town of Williams at $0.947 per sq. yd. or $10,322.30 in all. Clark & Henery Construction Co. bid $10,355. Engineers' estimate was $7521.

F. C. McIntire, Stockton, was low bidder for construction of 11 miles of state highway in Monterey county between San Lucas and San Ardo at the following unit prices: excavation, $0.75 per cu. yd.; 12-in. corrugated pipe, $0.50 per ft.; 18-in. pipe, $0.55; 24-in. pipe, $0.60; 36-in. pipe, $1; concrete in culverts and monuments, $14 per cu. yd.; concrete in pavement, $5.60 per cu. yd.; pile jetty complete, $2200; riprap in retaining-wall, $4 per ton; slope-paving, $6.50 per cu. yd.; guard-rail, $0.60 per ft.; monuments, $0.90 each; a total of $117,268.10. Other bidders were George S. Benson & Sons, $127,086.50; Roger Bros Co., $134,173.50; Bates & Borland, $134,688.50; Eaton & Smith, $151,641.50. Engineers' estimate was $99,473.85. State will furnish reinforcing steel, corrugated pipe, cement, sand, and coarse aggregate.

No bids were received for construction of concrete pavement on 7.4 miles of state highway between Beatrice and Eureka in Humboldt county, concrete pavement on 11.7 miles of highway in Tehama county between the southerly boundary and Los Molinos, or gravel surfacing on 12.7 miles of highway in Tehama county between Red Bluff and the northerly boundary. This is the second time that these three jobs have been advertised without bids being received.

Unit prices named by F. Rolandi, who was low bidder for construction of 15.9 miles of state highway between Redding and Tower House, were as follows: excavation, $0.87

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per cu. yd.; rubble masonry in retaining-walls, $6 per cu. yd.; dry-rubble masonry in retaining-walls, $8 per cu. yd.; concrete in culverts and monuments, $25 per cu. yd.; 12-in. corrugated pipe, $0.75 per ft.; 18-in. pipe, $1 per ft.; 24-in. pipe, $1.20 per ft.; new property-fences, $300 per mile; moving and re-setting property-fences, $300 per mile; monuments, $1 each; a total of $185,864. A. J. Fairbanks bid $323,038. Engineers' estimate was $169,413.80. State will furnish reinforcing-steel, corrugated pipe, cement, and material for new fences, valued at $24,093.

H. C. Flinn, 785 Market street, San Francisco, was low bidder at $1.10 per cu. yd. or $11,000 in all for grading 2.75 miles of state highway in Marin county between Ignacio and Black Point. Other bidders were J. P. Holland, $13,500; Edward Malley, $16,000; Frank McIntire, $16,400; A. J. Grier, $16,800; Western Contracting Co., $27,000. Engineers' estimate was $14,375.

**Salem, Ore.**—Plans have been approved by State Highway Commission and the U. S. Office of Public Roads for construction of the Ochoco forest-road, 9.7 miles. Estimated cost is $52,500, which will be shared equally by the Federal, State, and county governments.

**San Diego, Cal.**—City engineer George Cromwell is preparing plans for construction of 4-in. concrete highway 20 ft. wide from Pacific Beach to La Jolla, 3 miles.

**San Francisco, Cal.**—Board of Public Works has awarded the following contracts for street work:

20th avenue between Lawton and Moraga streets to Pacific States Construction Co. at $0.60 per cu. yd. for embankment and $0.158 per sq. ft. for concrete sidewalks.

Ninth avenue between Noriega and Ortega streets to Pacific States Construction Co. at $0.168 per sq. ft. for concrete sidewalks.

Ulloa street near 18th avenue and 23rd avenue between Rivera and Santiago streets to State Improvement Co. at $1.20 per ft. for concrete curbs, $0.19 per sq. ft. for broken-rock pavement, and $0.18 per sq. ft. for concrete sidewalks.

Seventh avenue between Lincoln way and Irving street to State Improvement Co. at $0.186 per sq. ft. for concrete sidewalks.

Crossing of Anza street and 40th avenue to C. B. Eaton at the following unit prices: concrete curbs, $0.80 per ft.; concrete sidewalks, $0.15 per sq. ft.; vitrified culverts, $1 per ft.; brick catch-basins, $80 each; asphalt pavement, $0.23 per square foot.

38th avenue between Cabrillo and Fulton streets to James M. Smith at the following unit prices: concrete curbs, $0.65 per ft.; concrete sidewalks, $0.11 per sq. ft.; vitrified brick pavement, $0.37 per sq. ft.; asphalt pavement, $0.225 per square foot.

Galcex avenue to Federal Construction Co. at the following unit prices: concrete curbs, $0.80 per ft.; concrete sidewalks, $0.16 per sq. ft.; asphalt pavement, $0.36 per sq. ft.; brick catch-basins, $125 each; 10-in. vitrified culverts, $1 per foot.

23rd avenue near Balboa street to James M. Smith at the following unit prices: excavation, $0.75 per cu. yd.; concrete curbs, $0.90 per ft.; asphalt pavement, $0.31 per sq. ft.; concrete sidewalks, $0.16 per square foot.

**San Rafael, Cal.**—Contract for grading, and construction of concrete curbs and gutters and water-bound macadam and richmondite pavement on streets in Granton Park tract at Kentfield has been awarded to S. P. Brownlee, San Rafael, for $13,000.

**Santa Ana, Cal.**—Contract for construction of topeka surface on the Dyer road has been awarded to Los Angeles Paving Co., Los Angeles, at 6.6c. per sq. ft. Other bidders were Orange County Engineering & Contracting Co., 6.95c.; Wells & Bressler, 7.9c.; Fairchild-Gilmore-Wilton Co., 8.5c.

Contract for construction of 1.86 miles of the Santa Ana Canyon road at Sulphur Slide has been awarded to Sharp & Fellows Contracting Co., Los Angeles, for $39,001. Other bidders were Los Angeles Rock & Gravel Co., $46,940; James Martin, $47,507; J. A. Hill, $49,065; H. E. Cox, $50,200; W. S. Mead, $55,778.25; Hewitt & Felch, $48,809; Fred Hoffman, $80,185; Richard Rothwell, $80,991.25; A. G. Wright, $96,348.50.

**Santa Barbara, Cal.**—Plans have been completed by O. H. O'Neill, county surveyor, for construction of concrete highway system connecting the Lompoc district with the state highway. Estimated cost is $500,000.

Fairchild-Gilmore-Wilton Co. was the only bidder at $4400 for construction of the Goleta road. Bid was rejected because too high and work will be done by day-labor.

**Santa Cruz, Cal.**—Contract for improvement of Rigg street has been awarded to W. E. Miller, Santa Cruz, at the following unit prices: excavation, $0.02 per sq. ft.; 5-in. concrete pavement, $0.125 per sq. ft.; 4-in. sewers, $0.50 per ft.; a total of $3150.71. Eaton & Smith bid $4026.39. Engineers' estimate was $3171.71.

**Seattle, Wash.**—Contract for construction of concrete sidewalks on 76th and adjacent streets has been awarded to W. H. Smith for $26,706.

Contract for construction of brick pavement on Rainier avenue between 51st and 57th streets has been awarded to R. G. Stevenson, for $32,009.

Contract for construction of brick pavement on Rainier avenue between Graham and Thistle streets has been awarded to the Sparker Construction Co. for $80,911.

Contract for construction of concrete pavement on permanent highway No. 19 between Tolt and Falls City has been awarded to Bancroft & Wright for $23,950. Other bidders were T. M. Morgan, $27,615; A. L. McGarry, $28,000; Kaiser Paving Co., $31,553; McRae Bros., $32,399. Engineers' estimate was $25,519.

**Spokane, Wash.**—Contract for construction of concrete pavement on 14th avenue has been awarded to H. C. Root, Spokane, for $13,100.

**The Dalles, Ore.**—Contract for improvement of several streets has been awarded to United Contracting Co., Portland.

**Vallejo, Cal.**—Contract for grading, paving, and construction of sewer, water, and lighting systems for group of residences and other buildings to be constructed for U. S. Housing Corporation for employees at Mare Island Navy Yard has been awarded to J. A. Marshall, Berkeley. Estimated cost is $250,000.

**Ventura, Cal.**—Fairchild-Gilmore-Wilton Co., Los Angeles, were low bidders for improvement of several streets in and adjacent to town of Fillmore at $0.135 per sq. ft. for 1½-in. asphaltic concrete pavement on 4-in. concrete base and $1 per cu. yd. for excavation, a total of $35,586.55. Bryant & Austin, Inc., Los Angeles Paving Co., and George H. Oswald also bid on this work.

**Woodland, Cal.**—County will improve roads near Broderick connecting with state highway. Estimated cost is $10,000. Work will be done by day-labor under the direction of T. S. Guile.

## SEWERS AND DRAINAGE

**Flagstaff, Ariz.**—McLean & Walsh, El Segundo, Cal., were the only bidders at $105,200 for construction of sewer system, including 41,650 ft. of 8 to 12-in. pipe and 114 manholes.

**Fresno, Cal.**—City engineer C. Murray has completed plans for sewer system for the North Fresno district recently annexed to city. Estimated cost is $162,000.

Contract for construction of septic tank at county fair grounds has been awarded to J. E. Mitchell, Fresno, on a cost-plus-percentage basis.

**Grandview, Wash.**—Contract for construction of sewer system has been awarded to C. H. Green, Spokane, for $35,000.

**Kingsburg, Cal.**—Fredericks & Shannon, Fresno, were low bidders at $30,976 for construction of sewage-disposal plant, including Imhoff tank. Johnson Bros., Kingsburg, were the only other bidders at $33,328.

**Long Beach, Cal.**—W. A. Frick, 440 South Daley street, Los Angeles, was low bidder at $89,000 for construction of sanitary sewers in district No. 4, requiring 69,000 ft. of 8, 10, and 12-in. vitrified pipe.

**Martinez, Cal.**—M. P. Holmes, 2400 Haste street, Berkeley, was low bidder for construction of main sewer system at the following prices: 8-in. vitrified pipe, $0.75 per ft.; 10-in. pipe, $1.08 per ft.; 14-in. pipe, $1.18 per ft.; 18-in. pipe, $1.54 per ft.; siphon under Alhambra cut, complete, $1444; 18-in. cast-iron pipe under right-of-way, $10 per ft.; manholes, $75 each; treatment plant, complete, $18,808; pumping plant complete, $6017; a total of $34,549. A. J. Reeder bid $35,037.70 and M. Murphy, $44,694. H. Gould bid $12,439.50 on the work exclusive of the pumping and treatment plants. M. P. Holmes was low bidder for construction of the Fairview sewer system at the following unit prices: 6-in. vitrified pipe, $0.86 per ft.; 8-in. pipe, $0.85 per ft.; 8-in. cast-iron pipe under right-of-way, $3.50 per ft.; manholes, $75 each; trestle and walk, $550; treatment tank complete, $250; a total of $2930. M. Murphy bid $5500. Both contracts have been awarded to M. P. Holmes. The septic tank for the Fairview system will not be constructed but the rest of the system will be built as planned.

**Merced, Cal.**—Formation of storm-water protection district containing 16,000 acres of land adjacent to Bear creek is proposed.

**Newport Beach, Cal.**—J. D. Kneen Contracting Co.,

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Santa Monica, was the only bidder at about $172,000 for construction of sewer system. Engineers' estimate was $100,000.

**Pasadena, Cal.**—Contract for construction of experimental sewage-disposal plant using the Trent process has been awarded by the cities of Pasadena, South Pasadena, and Alhambra to L. C. Trent Co. for $7000. If the process proves satisfactory all the sewage of the three cities will be treated in this way.

**Sacramento, Cal.**—Contract for construction of 8-in. sewers on several streets has been awarded to J. W. Terrell.

**San Francisco, Cal.**—Contract for construction of sewer on Carrie street has been awarded to P. A. Belser at $2.50 per ft. for 12-in. vitrified sewer and $2.50 each for wye-branches.

## BRIDGES AND CULVERTS

**Baker, Ore.**—Bids will be received until September 7 by county clerk for construction of three steel bridges with concrete abutments on county highways.

**Marysville, Cal.**—Contract for construction of highway bridge at Frenchtown has been awarded to D. C. Hogue, Frenchtown, for $975. Other bidders were Reynolds & Simmons, $1118.50; David Yore, $1443.19; F. H. Nelson, $1944.

Western Pacific Railroad Co. will construct steel and reinforced concrete bridge at Fifth and K streets. Estimated cost is $35,000.

Contract for construction of bridge over Reed's creek near Arboga has been awarded to H. A. Jenkins, Sacramento, for $3342.

**Merced, Cal.**—Contract for construction of reinforced concrete bridge on state highway between Merced and Athlone has been awarded to E. K. Angle for $2400.

**Modesto, Cal.**—Bids will be received until September 12 by H. Benson, county clerk, for construction of two reinforced concrete arch-bridges over Orestimba creek near Crows Landing and one reinforced concrete girder bridge across an irrigation canal near Newman.

**Napa, Cal.**—Contract for construction of reinforced concrete bridge in Pope valley has been awarded to Harry Thoreson, Napa, for $1120.

No bids were received for construction of concrete bridge across Putah creek.

Contract for construction of a masonry bridge across the Napa river near the Kellett ranch has been awarded to Harry Thoreson, Napa.

**Oakland, Cal.**—Contract for making repairs to the Webster Street bridge over the estuary has been awarded to Healy-Tibbitts Construction Co., San Francisco, for $44,709. Other bidders were Hyde-Harjes Co., $44,839; Tibbitts-Pacific Co., $47,018; J. D. Hannah, $52,727.50.

Bids will be received until September 10 by George E. Gross, county clerk, for construction of a reinforced concrete bridge on the Eden road.

**Oroville, Cal.**—Contracts for construction of two bridges, one on the state highway north of Chico and one across Angel slough on the Dayton road have been awarded to T. H. Polk, Chico, for $2474 and $9943, respectively.

**Sacramento, Cal.**—F. F. Moore & Co., Santa Barbara, was low bidder at $10,995 for construction of reinforced concrete bridge in Santa Barbara county on state highway across Canadal del Refugio near Orella. J. P. Hunter bid $15,500. Engineers' estimate was $8726.25. State will furnish reinforcing steel, cement, sand, and coarse aggregate, valued at $4609.06.

G. W. Harding, Los Angeles, was low bidder for construction of a reinforced concrete bridge across San Luis Rey river near Oceanside, at $41,490. W. M. Ledbetter bid $42,865 and Ross Construction Co., $43,400. Engineers' estimate was $30,151.25.

**San Diego, Cal.**—Contract for construction of reinforced concrete bridge on state highway across Santa Margarita river near Oceanside has been awarded to Wright & Dorn for $68,000. Other bidders were Macrae & Layaz, $73,444 and Pacific Building Co., $81,916.

Contract for construction of reinforced concrete bridge at Buckman Springs has been awarded to L. E. C. Smith for $6180. William F. Riley bid $6933.

**San Jose, Cal.**—Bids will be received until September 16 by H. A. Pfister, county clerk, for construction of reinforced concrete bridges across Ross creek on the Kirk road and on Luther avenue.

Bids will also be received until the same time for construction of bridges and retaining-walls on the Saratoga Turnpike road.

Contract for construction of reinforced concrete bridge on the Roberts road across Los Gatos creek has been awarded to Cacitti & Moore for $7275.65. R. H. Jamison bid $8451 and John W. Williams $9000. Engineers' estimate was $7600.

John W. Williams was the only bidder and was awarded the contract at $3544 for construction of reinforced concrete box-culverts on the Arastradero road and on Purissima avenue. Engineers' estimate was $3443.

Contract for construction of seven reinforced concrete bridges on the Page Mill road has been awarded to John W. Williams, the only bidder, at $15,000. Engineers' estimate was $14,750.

**Santa Barbara, Cal.**—Contract for construction of a reinforced concrete bridge across Picay creek has been awarded to C. J. Erickson for $2275.

**Tacoma, Wash.**—Following bids were received for construction of bridge across Nisqually river at Elbe: J. R. Wood, $14,250 for wood and $18,325 for steel; Illinois Steel Co., $19,900 for steel; S. E. Erickson, $11,674 for wood and $19,985 for steel; C. G. Huber, $13,995 for wood and $17,985 for steel; Henricks-Skillings Co., $15,785 for wood. Contract was awarded to C. G. Huber, Seattle, for steel.

**Willows, Cal.**—Contract for construction of the Clarks Valley bridge south of Fruto has been awarded to Teal & Thompson, Orland, for $3000. Bridge will be of reinforced concrete.

**Woodland, Cal.**—Following bids were received for construction of reinforced concrete bridge across Cache creek near Woodland: C. E. Cotton, $43,300 according to county plans and $39,900 according to own plans. Ross Construction Co., $43,800 according to county plans and $38,000 according to own plans. Bids were rejected and work will be done by day-labor under direction of county surveyor A. G. Proctor.

## IRRIGATION AND WATER SUPPLY

**Bishop, Cal.**—Contract for construction of concrete and rock-fill dam at Rush Creek meadows in Mono county 80 miles north of Bishop for Nevada-California Power Co. has been awarded to F. L. Somers, 260 East Holt avenue, Pasadena, for $50,000. Dam will be 400 ft. long and 50 ft. high.

**El Paso, Tex.**—Bids will be received until October 1 at office of U. S. Reclamation Service for construction of canals on the Rio Grande project near Hatch, New Mexico, requiring 63,800 cu. yd. excavation.

**Knightsen, Cal.**—Formation of irrigation district containing 10,000 acres in this vicinity has been proposed. E. A. Bridgford is interested.

**Livingston, Mont.**—Contract for construction of reservoir for municipal water system has been awarded to Richard Hooper, Livingston, for $27,507.

**Modesto, Cal.**—Contract for widening and lining with concrete the main canal of the Modesto irrigation district from the secondary headgates to the Mill gulch, about one mile, has been awarded to W. J. Schmidt, Berkeley, for $61,000. W. A. Kraner bid $64,270.

**Richmond, Cal.**—Contract for laying 6-in. cast-iron pipeline to the municipal wharf has been awarded to G. W. Cushing, Richmond. Contract for furnishing pipe has been awarded to United States Cast Iron Pipe Co. Total cost of line will be $9027.

**San Diego, Cal.**—Contract for construction of water system at naval coaling station at La Playa has been awarded to Henry Clarke Co., Los Angeles, for $13,543.

**San Francisco, Cal.**—J. D. Hannah, San Francisco, was low bidder at $59,700 for construction of 4800 ft. of submerged 6-in. pipe-line from Oakland pier to Goat island. Healy-Tibbitts Construction Co. and T. Crowley were the only other bidders at $64,942 and $69,800 respectively.

State Water Commission has granted the following permits to divert water for irrigation:

Knox & Leiser, Grafton, 2.27 second-feet from Sacramento river. Plans include 12-in. centrifugal pump.

J. F. Mallon and R. E. Blevins, Colusa, 100 second-feet from Sacramento river. Plans include one 36-in., one 30-in., and two 18-in. centrifugal pumps direct-connected to electric motors, one 30-in. pump belt-connected to a motor, a concrete-lined receiving reservoir, and a main canal 10½ miles. Estimated cost of work is $80,000.

Herbert J. Hammond, Little Rock, 1 second-foot from underground flow. Plans include shaft, pumping plant, and pipe-line 2½ miles long. Estimated cost is $5000.

F. W. Gundlach, Ruth, ¼ second-foot from Mad river.

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Plans include 3-in. centrifugal pump and 7-hp. engine. Estimated cost is $2500.

Austin Kramer, Grafton, 1.45 second-feet from Sacramento river. Plans include 12-in. centrifugal pump and ditch one mile long. Estimated cost is $6000.

J. N. Tedford, Red Rock, 2216 acre-feet per year from Canyon creek in Lassen county. Plans include diversion-dam, storage-dam, and ditch one mile long. Estimated cost is $15,000.

W. W. Bird, Los Angeles, 45 second-feet from springs and creeks in Inyo county. Plans include pumping-plants, ditches, pipe-lines, and diversion-dams. Estimated cost is $25,000.

Southern California Edison Co., Los Angeles, 120 second-feet from Pitman creek for direct diversion and storage in Huntington lake and 3781 acre-feet per year for storage in Pitman Creek reservoir. Plans include reinforced concrete multiple-arch dam and conduits. Total estimated cost is $842,000. Work is to be completed on or before June 21, 1921.

**Seattle, Wash.**—Contract for construction of water-mains on Baker avenue and adjacent street has been awarded to F. M. Badolato for $10,367.50.

Contract for construction of water and sewer system at the Salmon Bay plant of the Gulowsen-Grei Engine Co. has been awarded to Wenzler & Ward, Seattle, for $21,000.

**Stockton, Cal.**—Election will be held September 21 to vote on formation of Woodbridge irrigation district. This project was considered at election recently and the formation of the district was defeated. The district as now proposed will contain 19,343 acres. Most of the land owned by opponents of the district has been eliminated.

**Vale, Ore.**—Contract for construction of concrete dam and extension of distribution system for the Warm Spring irrigation district has been awarded to the Shattuck-Edinger Co., San Francisco. Estimated cost is $400,000.

**Yakima, Wash.**—U. S. Reclamation Service will spend $250,000 on raising sides and construction of concrete lining on the Tieton canal. Work will be in charge of G. W. Finley, with headquarters at Rimrock and will be completed by December 1.

## RIVER AND HARBOR WORK

**Los Angeles, Cal.**—City council has decided to appropriate $130,000 for construction of wharf at the east side of the main channel at San Pedro.

**Portland, Ore.**—Port of Portland Commission has decided to construct coal-storage dock at St. Johns. Plans are being prepared by the Rasmussen-Grace Co. Estimated cost is $75,000.

**San Diego, Cal.**—Ross Construction Co., Sacramento, was low bidder at $208,950 for construction of marine railway at the naval coaling depot at La Playa. Henry Clark bid $273,962 and San Francisco Bridge Co., $274,000.

**San Francisco, Cal.**—Contract for construction of 200-ft. extension to pier No. 21 has been awarded to Healy-Tibbitts Construction Co., San Francisco, for $43,733.

Informal contract for construction of fire-protection system for piers No. 31, 33, and 41 and bulkhead buildings No. 31 and 41 has been awarded to Scott Co., San Francisco, at $2900, $1848, $2843, $2465, and $2998, respectively.

Healy-Tibbitts Construction Co., San Francisco, was awarded contract at $43,733 for construction of extension to pier No. 21. Thomson Bridge Co. bid $43,900 and J. D. Hannah, $43,973. There were several other bidders.

**Seattle, Wash.**—G. H. Nicholson, engineer for the Port of Seattle Commission, has completed plans for wharves and warehouses at the Smith Cove terminal. Total estimated cost is $3,240,000. Election will be held in September to vote on bond issue of $1,250,000 for commencing this work.

## RAILROAD WORK

**San Francisco, Cal.**—U. S. Railroad Administration has decided to double-track Southern Pacific railroad between Bakersfield and Bena and between Tehachapi and Mojave, 32 miles in all.

## BUILDING CONSTRUCTION

**Arbuckle, Cal.**—Corporation has been organized to rebuild hotel recently destroyed by fire. Building will be of concrete. Estimated cost is $50,000, of which $33,000 has already been subscribed. F. W. Schutz is treasurer.

**Bay Point, Cal.**—E. W. Cannon, Central Bank Bdg., Oakland, will have charge of construction of cottages to be erected for employees of Pacific Coast Shipbuilding Co. by U. S. Housing Corporation. Estimated cost is $500,000.

**Fresno, Cal.**—Contract for construction of building for Kirk school has been awarded to James L. Daly, Fresno, for $41,840. Contract for construction of heating system has been awarded to William H. Cox, Fresno, for $5606.

**Fullerton, Cal.**—All bids for construction of one-story concrete mechanical-arts building for high-school have been rejected because too high. Plans will be revised and a new call for bids issued.

**Hamilton City, Cal.**—Bids will be received until September 7 by James Mills, Sr., president board of school trustees, for construction of school-building. Plans for W. H. Weeks, 75 Post street, San Francisco, upon deposit of $20.

**Jerome, Ariz.**—United Verde Copper Co. will construct a number of dwelling and apartment houses for employees.

**Kelseyville, Cal.**—Bids will be received until September 15 by school clerk for construction of frame school-building. N. R. Coulter, 46 Kearny street, San Francisco, is architect.

**Long Beach, Cal.**—Markwell Bros. will complete class A building commenced by them some years ago but never finished. The steel work is in place but the other work remains to be done. Estimated cost is $350,000.

**Los Angeles, Cal.**—Llewellyn Iron Works will construct reinforced concrete office-building. Estimated cost is $17,500.

Contract for construction of reinforced concrete storage-building for Lasky Film Corporation at Hollywood has been awarded to Jacobs Construction Co., H. W. Hellman Bdg., Los Angeles, for $19,200.

Contract for construction of brick building on Spring street near Seventh for A. E. Rose has been awarded to Milwaukee Building Co., Black Bdg., Los Angeles, for $49,029.

**Moscow, Ida.**—Contract for construction of addition to administration building at University of Idaho has been awarded to Roth Construction Co., Lewiston, for $37,575.

**Oakland, Cal.**—L. S. Rosener, Insurance Exchange Bdg., San Francisco, will have charge of construction of extension to machine-shop for Moore Shipbuilding Co. Estimated cost is $39,000.

Contract for construction of brick-and-concrete bakery-building for Remar Manufacturing Co. at 46th and Adeline streets has been awarded to J. A. Marshall, 3967 Avalon avenue, Berkeley, for $150,000.

**Orland, Cal.**—All bids for construction of Carnegie library exceeded the amount available and were rejected.

**Oroville, Cal.**—Bids will be received until September 10 by C. F. Belding, county clerk, for construction of detention-home. Chester Cole, Chico, is architect.

**Palo Alto, Cal.**—Following bids were received for construction of brick school-building in the Ravenswood district: W. D. Henderson, $16,678 (awarded contract); R. Kellaer, $16,862; F. W. Fox, $17,680; H. A. Klyce, $18,408; O. C. Holt, $18,480; J. S. Hannah, $18,527; Ruegg Bros., $18,875; W. H. Gibson, $21,384.

**Rio Vista, Cal.**—Contract for construction of reinforced concrete school-building has been awarded to Trevia & Pasqualetti, San Francisco, for $29,680. Contract for heating system has been awarded to J. C. Hurley, San Francisco, for $3295.

**Riverdale, Cal.**—Contract for construction of building for Riverdale Co-operative Creamery Co. has been awarded to Oscar Frederickson and George R. Shannon, Fresno, for $20,000.

**Sacramento, Cal.**—Following bids were received for construction of buildings at State School for Girls at Ventura: T. E. Hill Co., $72,671; G. M. Easton, $73,000; Edwards & Wildey, $74,000; E. E. Etherton, $77,234; J. B. Dawson, $77,839; Kier Construction Co., $79,400; R. W. Moller, $81,556; E. Gallagher, $82,700; Los Angeles Planing Mill Co., $82,835; L. G. Bergren & Son, $90,472. Following bids were received for construction of plumbing, heating, and sewer system: Arthur Hess, $17,087; T. Hagerty, $18,200; Richardson & Tyler, $18,660; J. E. O'Mara, $19,590; Robert Dalziel, Jr., $20,000; E. P. G. Nitzinger, $21,002; F. J. Llimm, $21,165; F. W. Snook & Co., $21,532; Perry & Spear, $22,820. All bids on general contract have been rejected and new bids will be received until September 16 by W. F. McClure, State engineer. Contract for plumbing, heating, and sewer systems has been awarded to Arthur Hess, Baker-Detwiler Bdg., Los Angeles.

E. E. Etherton, San Francisco, was low bidder at $119,900 for construction of several buildings at tuberculosis sanitarium to be established at Weimar by several counties in central California. Other bidders were Mathews Construction Co., $122,922; W. C. Duncan & Co., $128,761; Monson Bros., $157,943.

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